THE
WORKING AND MANAGEMENT
OF AN
ENGLISH RAILWAY.

THE WORKING AND MANAGEMENT OF AN ENGLISH RAILWAY.

BY
GEORGE FINDLAY,

LIEUT.-COL. ENGINEER AND RAILWAY VOLUNTEER, STAFF CORPS; ASSOC. INST. CIVIL ENGINEERS; GENERAL MANAGER OF THE LONDON AND NORTH-WESTERN RAILWAY.

WITH NUMEROUS ILLUSTRATIONS.

Second Edition, Revised and Enlarged.

LONDON:
WHITTAKER & CO.,
WHITE HART STREET, PATERNOSTER SQUARE;
GEORGE BELL & SONS, YORK STREET, COVENT GARDEN.

1889.

AUTHOR'S PREFACE.

IN the early part of last year I accepted an invitation from the Commandant of the Royal Engineers at Chatham to lecture at the School of Military Engineering at the Brompton Barracks upon the subject of "The Working of an English Railway." On that occasion, the theme was necessarily approached from the point of view of the utility of the railways in the event of the country being invaded; and although this led up to a description, within certain limits, of the methods of working and managing the railways, there were, of course, many branches of the subject which could not be brought within the scope of an evening's lecture, and would indeed scarcely have interested the audience to whom it was addressed. The lecture, however, in the printed form in which it afterwards appeared, attracted a certain amount of attention on the part of those interested in such matters, which eventually resulted in a suggestion that I should endeavour to deal with the subject in a more comprehensive manner than had previously been contemplated. The result of my attempt (I fear a very inadequate one) to carry out this suggestion is embodied in the following pages.

I must not omit to acknowledge my obligations to Mr. Francis W. Webb, the Chief Locomotive Engineer of the London and North-Western Railway; to Mr. Harry Footner, the Assistant Engineer; to Mr. A. M. Thompson, the Signalling Superintendent; Mr. J. W. Fletcher, the Telegraph Superintendent, and to the other Chief Officers and Heads of Departments of that Company for the able assistance they have rendered to me in the preparation of the work, and I must further confess my indebtedness to the valuable "History of the English Railway," published by Mr. John Francis in 1851, and to the "Treatise on the Law of Carriers," published by Messrs. Chitty and Temple, Barristers-at-Law, in 1856, both of which works had great interest for me during my early career as a Railway Manager.

In Chapter XV. of the present edition of the work, I have endeavoured to make what I trust may be a useful contribution to the discussion of a subject which has been, in recent years, much debated in railway circles, viz., the Composition of Passenger Trains and the Relation of the Classes. I scarcely venture to hope for universal concurrence in the views which I have expressed, but I know they are fully shared by many of those best qualified to form an opinion upon the subject, and I hope at least that the enumeration of the undoubted facts which I have been able to adduce as the result of actual experience, may have the effect of inducing those most interested to bestow their serious attention upon a question having so much importance for those whose capital is invested in English railway enterprise.

G. F.

Hill House, Edgware, 1889.

CONTENTS.

AN ENGLISH RAILWAY.

CHAPTER I.

Introductory and Retrospective.

It may at first sight appear that the subject of "The construction, working, and management of an English Railway" is one calculated only to enlist the attention of a limited class, namely, of those who are, or may be, directly or indirectly, connected with the working of railways, either in this country or abroad, but a little reflection will probably suffice to show that the theme is one which should appeal to a much larger circle of readers, and, in fact, to almost every class of the community. If the attention of an individual is drawn to any new law, any fresh discovery or social reform calculated to promote his personal comfort or well-being, his interest is at once aroused; and the circumstance that, in this case, the revolution has been effected and the benefit is actually being reaped should surely not suffice to rob the subject of its interest. The railway, in its present phase of development, enters so intimately into the social life of the community in its every detail, and has become so potent a factor in its every movement and operation, whether of business or of pleasure, that it must clearly be material for every individual to know something of the great agency which does so much for his happiness and welfare, and to realise clearly what are its obligations and liabilities towards himself, and what he has a right to expect from it. Such knowledge it is hoped this work may impart; but it has the further aim of constituting a practical guide or hand-book for those who, whether in this country or in our numerous colonies, may find it necessary, for whatever reasons, to acquire a knowledge of the principles upon which a great English railway is constructed and managed, and the methods and appliances by means of which its business is carried on.

It is not the intention of the present writer to enter into a detailed history of the conception and growth of the railway system from its earliest period to the present time. The story is one full of interest, and, having been recounted by many other and abler pens, may, in its main features, be said to be fairly well known. It may not, however, be out of place to allude, briefly, to the state of things which prevailed before the genius of a great engineer and the courage and enterprise of a few Liverpool merchants inaugurated the enormous social revolution which has since displayed such extraordinary development, and has so greatly contributed to the happiness and prosperity of the human race.

If we go no further back than the commencement of the present century, only a few years before the first railway was projected, we find that, although the difficulties of earlier locomotion had been to some extent obviated by the introduction of fast and well-appointed coaches, running between some of the most important cities in the kingdom, the only means of communication between the smaller towns was by means of post-chaises, or private carriages for the wealthy, and, for the less well-to-do, the humble carrier's cart or the slow and ponderous stage waggon. Travelling was so expensive a luxury that a journey was only undertaken under the most pressing necessity; many of the roads were so ill-constructed that in bad weather they were almost impassable, besides being at all times infested by highwaymen and footpads. Merchandise was conveyed from town to town by heavy and slow-moving waggons, and the cost of land carriage between Manchester and Liverpool, a distance of not more than thirty miles, was forty shillings per ton. To-day, Manchester bales are carried to Liverpool by railway at six shillings and tenpence per ton, and they are conveyed to London, a distance of upwards of 180 miles, for twenty-five shillings per ton. In those days, a journey from London to Birmingham, if all went well, and no mishaps were encountered, occupied ten or twelve hours at the least; while now a man of business may break his fast in London, be in Birmingham before noon, transact his affairs, and be back in town before dinner. At that time a journey from London to Scotland was something to ponder well upon before it was undertaken, for, apart from heavy expense and dangers, difficulties and fatigue to be encountered, it occupied several days; whereas now, a traveller may leave London at 8.0 p.m. or 8.50 p.m., can retire to rest as comfortably as if he were in a well-appointed hotel, and awake in the early morning to find himself in Glasgow or Edinburgh, or even further north. Merchants are able to be in frequent personal communication with their correspondents in the most distant towns; young folks, exiled from their homes in pursuit of their various careers, are enabled to spend even the shortest holiday in the family circle; letters posted in the evening are read at breakfast tables hundreds of miles distant the following morning; coals and every necessity of life are cheapened to the consumer, and every branch of business has been enormously stimulated and developed by the facilities thus brought to bear upon it; and, in fact, the speed and certainty with which the inland and import and export trade of the country is carried on are nothing less than astonishing. Goods are punctually collected, carried hundreds of miles between all the most important towns in England, and delivered to their consignees within the day of twenty-four hours, and even between England and places in Scotland, and the seaport towns of Ireland, within forty-eight hours. The Yorkshire manufacturer who attends the London wool sales to-day can have the wool he purchases in his warehouse to-morrow. The Lancashire cotton spinner will buy cotton in the Liverpool market one day, and it will probably be in actual consumption in his mill the next. Dead meat from Scotland and from abroad, poultry, butter and eggs from Ireland, vegetables, fruit, and all perishable goods of the kind, are despatched by the growers with the narrowest possible margin of time to catch a particular market; and all this is done with the utmost certainty and punctuality, making allowance, of course, for trifling miscarriages, which will occur in every large business, often from circumstances that nc foresight could control.

Such are a few of the advantages which have resulted to the community from the invention of railways, but the list might be multiplied indefinitely.

The first dawn of the idea of a railway was, no doubt, about the beginning of the seventeenth century, when some inventive genius hit upon the plan of laying down parallel blocks of timber to form tram-roads in the vicinity of mines, to enable the mineral products to be drawn more easily by horses to the riverside. More than a hundred years later (about the year 1768), as we are told by Mr. Francis in his admirable "History of the English Railway," cast-iron rails were substituted for the wooden blocks, and this was a distinct step in advance. By the commencement of the nineteenth century, the application of steam as a motive power was no longer unknown, for it had been applied to the working of stationary engines in mines and elsewhere, and, in fact, as early as 1804, a machine had been constructed at a Welsh ironworks, which moved upon rails, drawing after it a load of ten tons of bar iron, and which was, to all intents and purposes, a locomotive engine. The construction of the Stockton and Darlington Railway followed in 1821, but the first railway made with public money, and for the public benefit, and which marks the birth of the railway system as we know it to-day, was the Liverpool and Manchester. The conflict which was sustained by the promoters of that undertaking with the forces of ignorance and prejudice was really the decisive one, and when the struggle was over and the battle had been won, the floodgates of enterprise were opened wide and the era of railways had commenced.

About the year 1820, the relations between Manchester, as the great manufacturing town of the north, and Liverpool, as the nearest shipping port, had created a large traffic between the two places, for the conduct of which the road waggons and canal barges had proved to be totally inadequate. In the year 1821, therefore, a committee of merchants of Liverpool was formed to draw up a scheme for the construction of a railway or tramway between Liverpool and Manchester, the question of the motive power to be employed being left for a time an open one as between horses and the steam engine, with which Mr George Stephenson was then experimenting. There was no idea at first of conveying passengers, but the scheme grew in importance as time went on, until at length it aroused a perfect storm of enthusiasm on the one side and of embittered opposition on the other. Much has been said and written as to the incredible lengths to which that opposition was carried by the enemies of the undertaking, and the story is one not without its painful, as well as its ludicrous, features, but it need not here be enlarged upon. Suffice it to say that every weapon that the prejudice and narrow-mindedness of the many, or the alarmed avarice of the few, whose interests were threatened by the impending change, could devise was brought to bear without scruple, even to the length of personal abuse and calumny levelled against the promoters. The most absurd statements were gravely put forward and believed in; the smoke of the engines would kill the birds, cattle would be terrified, and cows would cease to give their milk; the sparks from the engines would set fire to the houses and manufactories on the line of route; the race of horses would become extinct, and many other direful consequences would ensue, amidst which the absolute ruin of the country would shrink to the insignificance of a detail! The first surveys had to be accomplished, in many cases, by stealth, and were, in some cases, resisted to the extent of the employment of armed force.

After the lapse of sixty years, we can afford to smile at the folly of those who seriously maintained such theories as these; but the opposition to be encountered was no laughing matter, we may be sure, to the earnest pioneers of the new movement who had staked their means and their reputations upon the issue of the undertaking, and devoted themselves heart and soul to the effort to carry it to a successful termination. At length, in March, 1825, the survey, in spite of all difficulties, had been completed, and the Bill was in Committee; but, after a lengthened discussion, extending over thirty-seven days, and chiefly owing to the opposition of the landowners and canal proprietors, it failed, and its enemies were for the time being triumphant. The sequel, however, shows that their exultation was premature and but short-lived.

The simile of Dame Partington striving with her mop to keep back the waves of the Atlantic is one sufficiently trite and well-worn, but it recurs almost irresistibly to the mind in contemplating the futile and hopeless attempt of these enemies of progress to arrest the march of that tremendous social revolution which, within the span of a single generation, was destined to change the whole face of the earth.

Nothing daunted by their first failure, the great engineer and his courageous backers returned to the charge. A fresh survey was made, by which many of the difficulties which had been raised were overcome or circumvented; the Bill was re-deposited in the ensuing session of Parliament, and this time the enterprise of its promoters was rewarded by success. The Bill received the Royal assent on the 7th May, 1826; the works were at once vigorously proceeded with, and the railway was actually opened for public traffic on the 16th September, 1830. It was, however, of a very different construction to the well-appointed and perfectly equipped railways of the present day. It consisted, it is true, of a double line of rails; but those rails were of so light a description that they soon succumbed to heavy wear and tear, and large sums had afterwards to be expended in taking them up and replacing them with others of a more substantial character. Instead of the timber sleepers, now universally in use, the rails were laid upon huge stone blocks, soon to be found expensive and unsuitable. The passengers were conveyed, either in open cars, unsheltered from the weather, or in covered carriages only a degree less comfortless, and presenting a strong contrast to the luxuriously appointed vehicles in which the traveller of to-day is accommodated. The trains, at first, started at irregular intervals, and were few and far between, and it was not until after some time had elapsed that the time-table became a recognised institution. The journey between Liverpool and Manchester, which is now easily accomplished in forty-five minutes, occupied at that time an hour and a half. Of the engines employed, more will be said hereafter; but it will be readily believed that they were of an extremely primitive character compared with those of a later date. As first projected, the railway terminated, at the Liverpool end, at Crown street, near Edge Hill, and omnibuses were employed for conveying the passengers to and from the City; but this was soon found to be a great hindrance to the development of the traffic, and in the session of 1832 powers were obtained for the construction of the tunnel under the City to Lime Street, which was completed and opened for traffic in August, 1836. Despite all its shortcomings, however, the undertaking was, from the very outset, a much greater success than even its authors had ever ventured to predict, and indeed their anticipations proved to have fallen almost ludicrously short of the results actually realised. They had expected to earn £10,000 a year from passenger traffic, whereas in the first year after the opening the receipts from that source were £101,829. They had estimated the gross receipts from merchandise at £50,000 per annum, but in 1833 the actual amount received was £80,000. From the very commencement, the shareholders obtained a dividend at the rate of 8 per cent. per annum, afterwards rising to 9 and 10 per cent., and remaining at the latter figure for some years.

The great success of the Liverpool and Manchester railway, as might naturally have been expected, let loose a flood of railway enterprise all over the country. Lines were soon projected between all the towns of any importance in the kingdom and even between remote villages. One enthusiast went so far as to propose a railway under the sea between Dover and Calais, and was no doubt looked upon by his contemporaries as a fitting candidate for a lunatic asylum, but probably the distinguished promoter of the Channel Tunnel scheme of to-day may hold a different opinion upon that point. The most important result that immediately followed, however, was the revival of the scheme which had previously been mooted, but had been abandoned, for the construction of a railway between London and Birmingham. The Bill for this line, which was the parent of the London and North-Western Railway, was first deposited in November, 1831; but, after passing the House of Commons, was thrown out in the House of Lords on the 10th July, 1832. The opposition to this Bill was as unscrupulous, and of precisely the same character, as that which its precursor—the Bill for the Liverpool and Manchester Railway—had had to encounter; but in the end it was overcome, and the line, having been sanctioned in 1833, was finally opened to the public in 1838.

For the purposes of this work, it is not necessary to follow, step by step, the gradual, yet rapid, development of the railway system throughout the country. It will be sufficient to record that by an Act obtained in 1846 the London and Birmingham, the Grand Junction (with which, under an Act obtained earlier in the same year, the Liverpool and Manchester Railway had already been incorporated), and the Manchester and Birmingham Railway Companies were amalgamated under the title of the "London and North-Western Railway Company." During the lapse of time since that period this Company has gradually absorbed the South Staffordshire, the Chester and Holyhead, the Lancaster and Carlisle, and some forty smaller companies, many of which, for a time, were only leased, and retained their separate capitals with varying rates of interest and, in some cases their independent boards of directors. But in 1877 an Act was obtained, commonly called the "Consolidation Act," the effect of which was to weld all these separate companies into one homogeneous undertaking, the London and North-Western Railway, as it exists to-day, having a consolidated stock of upwards of £108,000,000, possessing more than 1,800 miles of railway, with nearly 650 stations, and employing a staff or an army, as it may be called, of 55,000 men.

It may here be stated that, although much of what follows may be taken as being more or less generally applicable to all the principal railways of the United Kingdom, yet the one, the working of which is more particularly described in the succeeding chapters, is the London and North-Western, with which the writer has been connected for a great number of years, and with which he naturally therefore possesses a more intimate acquaintance than with any other.

CHAPTER II.

MANAGEMENT.

THE administration of the London and North-Western Railway is carried on by the Chairman, two Deputy-Chairmen, and a Board of thirty Directors, five of whom retire annually, but are eligible for re-election. Any shareholder may become a director by election, provided he possesses the qualification of holding ordinary stock to the value of one thousand pounds. The full Board of Directors meets once a month, viz., on the third Friday in every month, but the members are also organised in a number of smaller committees, called "Committees of the Board," which also meet once a month and deal with various branches of the business. For instance, there is a "Special Committee," consisting of sixteen members, which holds its meetings intermediately between the meetings of the full Board and devotes itself to much the same class of business; a "Finance Committee" of seven members; a "Permanent Way Committee" of ten members, at which the engineers attend, and which accepts tenders, approves contracts, orders relaying and repairs, and generally authorises all expenditure connected with the permanent works of the railway; a "Locomotive Committee" of ten members, which deals with all matters relating to the engine works at Crewe, the carriage works at Wolverton, the waggon works at Earlestown, and everything connected with the rolling stock of the railway and with the steamboats. There are also a "Fares and Rates Committee" of eight members, and a "Debts and Goods Claims Committee" of ten members, the titles of which sufficiently indicate their functions, and an important committee called the "Traffic Committee," composed of fifteen members, which approves changes in the staff and in the pay of the Company's servants, authorises expenditure upon new works, and deals, besides, with a variety of other matters connected with the discipline of the staff and the working and accommodation of the traffic. In addition to these there are smaller committees for the hotels and refreshment rooms, for legal and medical business, and for stores. At the meetings of the full Board, which are presided over by the Chairman of the Company, the minutes of all these various committees are submitted and approved or otherwise as the case may be, and the Board also deals with Parliamentary matters, questions of policy, proposals for new works involving large expenditure, and, generally, with all business of the first importance affecting the Company. The present Chairman of the Company, as is pretty well known, is an extremely hard worker, and has for many years devoted the whole of his time and his great talents for administration and finance to the service of the Company which he has done so much to place in its present position at the head of the railway enterprise of the country.

The executive management of the line is carried on by a General Manager, a Chief Goods Manager with two assistants (one for the outdoor working, and one for the indoor work, the making of rates, etc.), and a Superintendent of the line with one assistant. These two last-named officials deal with the working of the trains, both goods and passenger, and all things pertaining to the movement of the traffic.

For administrative purposes, the entire system is divided into ten sections or districts, each of which is under the control of an officer of tried and practical experience, termed the "District Superintendent," having his offices at some central point, who is responsible for the train arrangements of his own district, the conduct of the traffic and the discipline of the staff. Each of these officers has under him an assistant and several travelling inspectors who regularly visit every station and signal post and investigate and report upon everything that is going on in the district, these men being, moreover, encouraged to make suggestions for the improved working of the trains and the avoidance of irregularities, any such suggestions always receiving careful consideration. In some of the less important districts the District Superintendents are responsible for the goods work at the stations as well as the conduct of the passenger traffic, and in that case they are answerable both to the Chief Goods Manager and to the Superintendent of the line; but, in six of the more important districts, they are relieved of the management of the goods business (except as to the working of the trains) by district officers of equal rank with themselves, who are called "District Goods Managers," and who are responsible to the Chief Goods Manager at Euston. The same principle is followed out with regard to the management of the stations, at the majority of which a single agent is placed in charge of both the goods and passenger traffic, while at 180 of the most important stations there are two officials, one of whom, called the "Station-master," attends to the passenger work, and is accountable to the District Superintendent,and the other, styled the "Goods Agent," is responsible for the goods working, and is under the control of the District Goods Manager.

It will thus be seen that the chain of responsibility and of supervision is a very complete one, and, in fact, the secret of organising the management of a great service, such as this, is nothing more than a carefully arranged system of devolution combined with watchful supervision. It is not, of course, practicable for the General Manager to superintend in person the every-day actions of the porter or the signalman, but these latter act under the immediate direction of the Station-master, the Station-master is accountable to the District Superintendent, the District Superintendent to the Superintendent of the line, the Superintendent of the line to the General Manager, and the General Manager to the Chairman and Directors. If anything goes wrong, or any mishap or irregularity occurs, each of these has to bear his own share of the responsibility in turn, and thus all are kept on the alert, and each one has an interest in seeing that those subordinate to him are fit and capable in every way to discharge the duties placed upon them.

There are two "Conferences" held every month (so called to distinguish them as meetings of *Officers* from the meetings of the *Directors*, which are termed "Com mittees"). The first is called the "Officers' Conference," and meets monthly, the meetings being held usually, but not invariably, at Euston. It is presided over by the General Manager, and is attended by the chief officers at headquarters, and by the whole of the district officers, both goods and passenger. One of the most important functions of this Conference is to discuss and decide upon all alterations of the train service, but it also deals with mishaps and irregularities in working, and considers the causes that have led to them, and the means of preventing a recurrence. Proposals for the alteration of rules and improved arrangements for conducting the traffic are also debated, and, broadly speaking, all matters affecting the working of the line, or the running of the trains come within the purview of this Conference.

The second of the two Conferences is termed the "Goods Conference," which also meets once a month, usually on the day preceding the meeting of the Officers' Conference, its chairman being the Chief Goods Manager, and the members being confined to those district officers who are responsible for the goods working. This Conference takes no cognizance of train arrangements, which are dealt with entirely by the Officers' Conference, but concerns itself with questions relating exclusively to the conduct of the goods traffic, such as mileage and demurrage, outstanding freight accounts, the supply of waggon stock, ropes and sheets, claims for goods lost, damaged, or delayed, cartage and agency and kindred subjects.

The minutes of both these Conferences, which are printed for more convenient distribution to all concerned, are submitted for approval to the Board of Directors, and until they have been so approved, the recommendations contained in them are not valid and cannot be acted upon.

The fact of all the country officers being brought together at headquarters once a month, primarily for the purpose of attending these Conferences, forms a very essential and valuable feature in the working of the line. They have thus the opportunity of meeting one another, comparing notes and exchanging experiences, besides which each of them in turn enjoys the advantage of a personal interview with the General Manager and with the other chief executive officers, in order to seek advice or instruction upon important and, perhaps, delicate matters which for various reasons can better be dealt with orally than by means of written reports. On the other hand, the chief officers themselves derive benefit from being brought in contact with the men who are engaged from day to day in supervising the actual working of the traffic, and are kept well posted in everything that is going on all over the system.

Another important feature is the system of periodical inspections. From time to time, some of the directors, accompanied by the chief officers, the engineers, and the district officers concerned, go over each district, visit the stations, and inquire into cases of alleged inadequate accommodation or other matters calling for attention. At other times, the chief officers, unaccompanied by the directors, visit the districts, inspect the stations, examine personally the principal stationmasters and inspectors, and satisfy themselves by careful inquiry that all the rules and precepts laid down for the efficient conduct of the traffic, and the safety of the line, are being scrupulously carried out throughout the system. Thus nothing is left to chance or to the possible carelessness of subordinates, but a jealous watchfulness is constantly exercised to ensure that all the necessary precautions that experience has dictated and authority has laid down are thoroughly and effectually observed.

Every servant of the Company, on his appointment, is presented with a copy of the "Rules and Regulations," and is expected to make himself master of its contents, but more especially of the section relating to the branch of the service to which he belongs. This book contains a complete *résumé* of the rules laid down for signalling, for the use of the block telegraph, and for the working of the line generally, and an intimate acquaintance with its contents is indispensable to any man who desires to make himself proficient in his duties. The book also contains the disciplinary rules of the service, and every *employé*, when on duty, is required to have his copy about his person so that he canno plead ignorance of his instructions as an excuse for neglect of duty.

The system of control over the expenditure of the Company's money is a very complete one. The general theory is that no expenditure whatever is incurred without the direct sanction of the Directors, expressed by a minute of some committee approved by the Board. The district officers are, indeed, allowed to make some small necessary payments, but even for these the vouchers are submitted monthly, and, after being carefully examined, are passed by the Finance Committee. No work is done by any of the engineering departments, except ordinary maintenance and repairs, without a minute of the Directors to sanction it, and, in like manner, no claim is paid, except those of very trifling amount, without the authority of the "Goods Claims Committee."

As might be expected, in an undertaking of such magnitude, and with a constantly fluctuating but nearly always growing, traffic, the Executive at headquarters is daily inundated with suggestions and recommendations for alterations and increased accommodation at stations and depôts, but these undergo a very searching examination before any effect is given to them. We will suppose, for example, that a goods agent conceives it to be necessary for an additional siding to be laid down at a station. He makes a report to that effect to the Manager of the district; the latter inquires into the facts on the spot, and, if he concurs in the necessity, reports his recommendation to the General Manager. The latter consults, in the first instance, the Chief Goods Manager or the Superintendent of the line, as the case may be, and, if his report be favourable, authorises the Engineer to prepare a plan and estimate. The plan, when ready, is subjected to the criticism of the District Officer, the Chief Officer, and of the General Manager, and, if all are satisfied, the Directors are next asked to authorise the necessary outlay. But even this is not all, for, finally, the plan has to be signed by the Chairman of the Company before the Engineer commences operations, and that gentleman, who keeps a watchful guard over the Company's purse strings, has to be convinced that the expenditure is not only desirable, but actually unavoidable, before his signature is obtained. Thus the shareholders may rest perfectly easy in the assurance that their money is not dissipated in needless accommodation works.

One very important part of the management of a railway, as may be easily imagined, is the arrangement of the train service. The entire service is re-organised twice in the year, viz., in the spring, to provide for the summer months, when the passenger traffic is heavy and the goods and coal traffic light; and again in the autumn, with a view to the winter months, when, conversely, the passenger traffic is light and the goods and coal traffic heavy. As far as is practicable, the changes are confined to these two periods; but, owing to fluctuations of business, the growth of new neighbourhoods, and all kinds of local and special circumstances, there is really no month in the year when a number of train alterations do not have to be considered and decided upon. This is done, as before stated, at the monthly meetings of the Officers' Conference, held during the third week of every month, and between that time and the end of the month the time-tables have to be revised and reprinted. No one who has ever glanced with an intelligent eye at the time-table of a great railway will be surprised to learn that this operation is one of the most complicated nature, and involving great labour and considerable skill. This will be apparent if it be borne in mind that, supposing, for instance, a train running from London to Scotland is altered in its timing ever so slightly, it involves the necessity of altering all the trains running on branch lines in connection with it, and many other trains which are affected by it. A train service is, in fact, like a house of cards; if the bottom card be interfered with, the whole edifice is disarranged, and has to be built up afresh. Remembering all this, and the pressure under which the work must be done, the wonder is not so much that an occasional error creeps into a time-table, as that such marvellous accuracy is, on the whole, arrived at.

The time-tables of the London and North-Western

Railway are printed at Newton-le-Willows, where the contractors for printing and stationery, Messrs. McCorquodale & Co., have their headquarters. To that town, within a few days of the train alterations having been decided upon by the Officers' Conference, there repairs a clerk from each of the ten districts who is called the "time-table clerk," and with these ten clerks comes an official from the office of the Superintendent of the line to supervise their labours and assist them with his experience. Taking the minutes of the Officers' Conference as their guide, these clerks proceed to revise the time-table, each working out the times for his own section of the line, but all comparing notes as they proceed so as to ensure a harmonious result. As they progress, the results of their labours are placed in the hands of the printers who are on the spot, and the proof-sheets are afterwards revised and corrected by the clerks who have prepared them, and this is how the time-table of the North-Western Railway is produced.

It is extremely difficult to lay down any hard and fast rules for the efficient management of the whole or a section of a large undertaking. If the man who is called to the task has a talent for organisation and administration, he will be a law to himself, and if he does not possess these qualifications, no stereotyped rules will avail to supply their place. There are, however, certain maxims which are elementary and upon which it may be worth while to insist, and these may be briefly summed up as follows :—

(1.) Every man should be chosen with special reference to his suitability for the duties he is called upon to perform. To use a familiar aphorism there should be no "round pegs in square holes."

(2.) Care should be taken that every man entrusted with a responsible duty is thoroughly trained for its performance and competent, before the responsibility is cast upon him.

(3.) Every man should be fairly remunerated for his labour, and should be, as far as it lies with the management to make him so, a cheerful and contented servant. A discontented man makes a bad servant, for his mind is often pre-occupied by his own real or fancied grievances when it should be concentrated on his employer's business.

(4.) Every man should have his duties thoroughly defined and should know exactly what is required of him. To use another aphorism, "What is every one's business is no one's business," or, in other words, a piece of service which is equally the duty of two or three men is likely to be well performed by neither, for each will shift it on to the others if he can, and the one who ultimately discharges it, will do so grudgingly, thinking the others might have done it rather than himself. Moreover, if, after all, it is neglected, it is difficult to fix the responsibility for the omission on any one individual.

(5.) There should be, at all times, active and vigilant supervision in every branch of the service. It is not enough that every man should be fit for his duties and trained for their performance, but it must be the duty of someone to see that he actually does perform them, and that no slackness or carelessness is allowed to supervene in carrying on the working from day to day. The railway service is pre-eminently one requiring for its efficient conduct a high degree of smartness, alacrity, energy, and zeal on the part of every individual engaged in it.

To anyone who may be called upon to occupy the position of a chief official in any great undertaking, such as the one herein described, one or two hints, the result of the writer's practical experience of five-and-thirty years, may not be without their value. The first discovery that any man makes on his being appointed to such a post is that if the day consisted of forty-eight hours instead of twenty-four, and every hour were devoted to his office, his time would still be insufficient to meet the demands on it. It thus becomes essential to economise time as a most precious commodity, and this is best accomplished by acting strictly upon the following maxims:—

(1.) Choose your subordinates carefully and well, and let them be men you can thoroughly rely on. Do not concern yourself too much with points of detail, with which you must be fully conversant, but with which they are just as well able to deal as you are, and reserve yourself for such matters of moment as they are not competent to decide without your authority and experience.

(2.) Before any question is submitted to you for decision, insist upon having all the details filled in, and all the facts before you, so that you may not have to apply your mind to it a second time, but may decide it once and for all with a full knowledge of all its bearings.

(3.) Always decline steadily to attempt to do two things at once. If you are giving an audience to one person, be it a head of department, or any other, let your door be rigidly closed to everyone else for the time being. Let "one at a time" be always your maxim, and act upon it strictly. The man in authority who is seen continually surrounded by a throng of subordinates and striving to meet all their demands at once is the man who, by reason of excessive wear and tear, is most likely to break down in mid-career and fail either in health or intellect; but the man who steadily concentrates his brain power upon one thing at a time, never wasting a moment, but never flurried or hurried, is the man who gets through the greatest amount of work with the least toil and harassment to himself and in the shortest possible time.

(4.) Always make a point of refusing (except, of course, in special circumstances) to see chance callers, who will otherwise occupy the best part of your time with trivial matters which could just as well be attended to by your subordinates. It is a good plan to make it a rule to see no one without an appointment made beforehand either in writing or through your secretary, or else without previously knowing their name and the nature of their business. It is very amusing, at times, to see the pertinacious attempts which are made to break through this rule, and it can only be maintained inviolate by the agency of a wily and imperturbable secretary, and an office which can only be approached through his. The man who has had a box delayed, the woman who conceives she has been overcharged in her fare, the discharged footman who seeks employment as a porter, will each and all insist upon seeing the general manager; each believes that no one else can or will give them a satisfactory answer, and it is often very difficult to get them even to disclose their business to another person.

CHAPTER III.

THE STAFF.

THE staff employed by the London and North-Western Railway Company (exclusive of the staff engaged upon lines owned jointly by the North-Western and other companies) consists at the present time of 55,217 persons of all grades, and these are made up as follows:—

Salaried officers and clerks	6,770
Drivers, firemen, guards, breaksmen, and signalmen	8,298
Other servants working at weekly wages in the various departments	40,149
Total	55,217

About 22,000 of these persons are engaged in one way or another in connection with the working of the traffic, the remainder being clerks, artificers, labourers, etc. A certain percentage are boys in training in the various departments, and the total includes about 130 girls and women who are employed at the principal goods stations in the performance of certain duties in connection with the accounts department, for which they are found to be peculiarly suitable. This experiment was first tried some years ago, and being found to be fairly successful, both on the score of economy and efficiency, is being gradually extended within certain limits.

To carry on the traffic of a great railway one of the main essentials is a highly-trained and thoroughly qualified staff, and it may justly be said that the companies spare neither trouble nor expense in securing and maintaining this most important requirement. The practice adopted by the London and North-Western Company, and it is, in the main, the one which is observed by all English Railway Companies, is to appoint lads about fourteen years of age as boy porters, telegraph boys, and for other similar employments; these lads grow up in the service, and by the time they reach manhood they have become experienced in railway duties in their various branches, and are eligible for filling such posts as become vacant. The most scrupulous attention is paid to the training of signalmen, a class of men the difficult and responsible nature of whose enployment can hardly be exaggerated, and they are never entrusted with the sole charge of signals until they have received a specific course of instruction in the duties. The period of training varies according to the importance of the posts at which the men are to be stationed, but their appointments are not confirmed until the superintendent of the division has certified that he has examined the men, and finds them to possess every qualification for the posts they are to fill, including freedom from colour-blindness, which is a fatal defect in a railway servant. The guards of passenger trains are usually chosen from the ranks of the porters; and the goods train guards, or brakesmen, are selected from the goods porters, shunters, and men of that class; but all these men are subjected to a rigid examination before being appointed, and due regard is had, not only to their knowledge and experience, but to their general intelligence, capacity, and character.

For the superior positions of inspectors, foremen, station-masters, and the higher grades of the service, it is the invariable rule to select men from the lower ranks, solely on the ground of merit, the best man for a particular post being chosen, irrespective of seniority or any other circumstance. Thus it is no unusual thing for a station-master, by reason of special aptitude, to rise to the position of divisional superintendent, and even of General Manager.

As regards the highest positions, at the time when railways were a new feature in the social life of the country, and their promoters looked around them for men suitable to direct their operations and control the large number of persons engaged in working them, they found none who, in their opinion, at that time, were so suitable as officers who had retired from the army and navy, it being supposed that their acquaintance with discipline, and the habits of command they had acquired in the pursuit of their former avocations, would stand them in good stead in their novel career. Thus, in connection with the London and North-Western Railway, we recall the names of Captain Huish and Captain Bruyeres; the North Eastern Company appointed Captain O'Brien as their general manager; the Lancashire and Yorkshire, Captain Lawes, R.N., and the Caledonian, Captain Coddington, R.N., besides other officers of the two services, whose names might be mentioned. As time went on, and the strictly commercial character of these great undertakings became more evident and pronounced, it was perceived that the duties of the highest positions in connection with them required for their efficient performance men who had received a business training, and were thoroughly acquainted with all the details of railway working. It thus became gradually the practice to promote men of talent and capacity from the lower ranks of the service, from one post to another, through the intervening grades, until they reached the highest positions attainable, and the present writer can recall, within his own personal experience, many cases in which men have risen from subordinate posts to become general managers of some of the most important railways in the kingdom.

Thus the humblest railway servant, if he does not, like one of Napoleon's corporals, carry a marshal's *bâton* in his knapsack, may at least contemplate a field of possible promotion of almost as wide a scope.

It is scarcely necessary to say that engine-drivers are very carefully trained for their duties before being entrusted with the charge of a locomotive. They usually commence service as lads in the engine sheds, where they are employed as cleaners; after a time they are promoted to be firemen; then to be drivers of goods trains; next to be drivers of slow or local passenger trains, and, ultimately, the most experienced and intelligent men are selected to drive the express passenger, and mail trains.

The Company are very far from being unmindful of the material welfare of the men they employ, and indeed it is their constant study to maintain the most cordial and friendly relations with them, and to make them feel that their employers have a sincere interest in them and in their well-being at all times, apart from the mere buying and selling of their labour; in fact, they are taught to regard their employers as their best friends and advisers, as should be the case in every department of labour where proper relations exist between master and man.

Several funds or societies have been established in connection with the Company's service, in order to enable every member of the staff to make prudent provision against the results of accident, sickness, death, or old age, and a brief description of the working of these societies, which, judging from the success which has attended their operations, may to some extent be regarded as models of their kind, may not be without interest.

The first, and in some respects the most important, is the "Superannuation Fund Association," which was also the first established, having been in existence since 1853, and is for the benefit only of the salaried officers and clerks of the Company, its object being to provide each contributing member with a superannuation allowance on his retirement from the service at the age of sixty years, or at any earlier period should his health permanently fail, provided he has been at the time of his retirement a paying member for ten years.

There is also a payment to the member's representatives in the event of his death before superannuation. Membership is compulsory upon every servant of the Company receiving a monthly salary, and is in fact made a condition of entering the service, with the proviso, that no person is permitted to become a member after the age of 26 years.

The members' contributions amount to 2½ per cent. per annum upon their salaries, deducted monthly from their pay, but the Company contribute, in respect of each member, an amount exactly equal to his own contribution. The accumulated balance is invested in the hands, and under the trust, of the Company, at such average rates of interest as the Company, from time to time, pay on their debenture bonds and mortgages, the interest being carried to the credit of the fund at the close of each half year. The fund is administered by a committee of six persons, three of whom are nominated by the directors, and three are elected by the members. In the event of the death of a member before superannuation, his representatives receive either the equivalent of half-a-year's average salary, calculated over the whole term of his contributions or the sum of his own contributions and those of the Company in his behalf, whichever be the greater. Any member retiring from the Company's service before superannuation, *bonâ fide* of his own accord, receives back one half the amount of his own contributions to the fund. A member whose engagement is terminated by the Company from any cause other than fraud or dishonesty receives the whole of his own contributions, but if he is dismissed for dishonesty, he may, in the discretion of the Committee, forfeit the whole.

Years of Contribution completed.	Superannuation in percentage of average salary.	Years of Contribution completed.	Superannuation in percentage of average Salary.	Years of Contribution completed.	Superannuation in percentage of average Salary.	Years of Contribution completed.	Superannuation in percentage of average Salary.
10	25	19	36	28	46	37	56
11	26	20	37	29	47	38	58
12	27	21	38	30	48	39	60
13	28	22	39	31	50	40	61
14	29	23	40	32	51	41	62
15	30	24	42	33	52	42	63
16	32	25	43	34	53	43	64
17	34	26	44	35	54	44	65
18	35	27	45	36	55	45 &upwards	67

The pensions of those members who remain in the service and claim them are calculated upon the foregoing graduated scale, to which, however, an addition of $\frac{1}{12}$ or $8\frac{1}{3}$ per cent. is made, in accordance with a supplementary regulation prescribed by the actuaries since the scale was laid down.

The fund has, at the present time, 5,705 members, its revenue amounting to £50,000 per annum, and its accumulated balance to considerably more than half a million sterling. Yet the actuaries who, in accordance with the Deed Poll, thoroughly investigate the position of the fund every five years, advise that the benefits are the maximum that can safely be accorded, consistently with maintaining the association upon a sound financial basis.

The "London and North-Western Insurance Society" was established in 1871, its object being to provide for every member of the wages staff, except those in the Locomotive Department (of whom more hereafter), pecuniary relief in cases of temporary or permanent disablement, arising from accident occurring while in the discharge of duty, and also a payment in all cases of death, whether the result of accident or natural causes. Membership of this Society is compulsory upon all men on joining the service, and each man is called upon to sign an agreement under which the Company undertakes to contribute to the funds of the Society a sum equal to five-sixths of the premiums from time to time payable by the *employé*, and the latter agrees to accept such contributions, and any advantages to which he may be entitled under the rules of the Society, in satisfaction of any claim which he or his representatives might otherwise have had under the provisions of the "Employers' Liability Act" of 1880. By these means, for a small payment, the men, or their families, become entitled to a substantial sum in case of death or disablement, without any delay or any question being raised as to the circumstances of the accident from which they suffer, and this is far more to their advantage than being left with the questionable privilege of claiming under the Act, with all the delay, expense, and doubtful result of legal proceedings. Moreover, a state of good feeling is engendered between the men and their employers which could not be the case to an equal extent if each were taught to look upon the other as a possible opponent in litigation, and any legislation such as has from time to time been threatened in the direction of preventing the men from contracting themselves out of the provisions of the Act is justly viewed by the majority of the London and North-Western *employés* with dislike and dread, and is much to be deprecated alike in their interest and that of their employers.

The premiums payable by the members are as follows:—

CLASS 1.—Passenger Guards, and Breaksmen, and (optionally) men of other grades receiving wages of 21s. per week and upwards	3d. per week.
„ 2.—All other Wages staff, except those in Class 3	2d. „
„ 3.—Boys and Persons whose Wages are under 12s. per week	1d „

The scale of benefits is as under :—

	Sum insured in case of death arising from accident whilst in the discharge of duty.	Allowance in case of permanent disablement and incapacity to resume employment arising from accident whilst in the discharge of duty.			Weekly allowance in case of temporary disablement by accident whilst in the discharge of duty. During continuance of disablement, not exceeding 52 weeks.		Sum insured in case of death from any cause not provided for in column No. 1.	
	£	£	s.	d.	s.	d.		
Class 1	100	100	0	0	21	0	£10	0
„ 2	80	80	0	0	14	0		
„ 3	40	40	0	0	7	0	5	0

The members elect delegates to represent them at the general meetings, viz., five for each of the twelve districts into which the line is divided, and the affairs of the Society are managed by a committee of 15 persons, 12 of whom are elected by the delegates from their own body, one representing each district, and three members are nominated by the Directors and are termed the "Company's nominees."

On the 31st December, 1888, this Society consisted of 39,602 members; its income for the year 1888 was upwards of £31,000, and it had an accumulated balance in hand of more than £23,000, the amount paid out to the members in the shape of benefits during the year being £29,148.

The "London and North-Western Provident Society," an offshoot of the Insurance Society, was established in 1874 with the object of providing a weekly allowance in cases of ordinary sickness for the men composing the wages staff of the Company (other than those employed in the locomotive department); a retiring allowance for permanently disabled members; and a sum at death in all cases not provided for by the rules of the Insurance

Society. There is also an allowance to meet medical and funeral expenses on the death of a member's wife. Membership is compulsory as a condition of service. The Company contribute £800 per annum to the funds of this Society in addition to crediting the fund with the fines inflicted upon their servants, and the scale of payments by the members and of benefits is as follows :—

Class.		Weekly Payments.	Sum insured in case of Temporary Disablement for work owing to Sickness or to Accident incurred while not in the discharge of duty, or from any cause not provided for in the Rules of the Insurance Society.	Sum insured in case of Death from other causes than that provided for by the Rules of the Insurance Society under the head of accident on duty, the deceased having been a Member during the six months immediately preceding his Death.	Payment upon death of Member's wife to meet medical and funeral expenses subject to approval of Committee in each case.	Retiring gratuity to be paid to Members in the event of their becoming disqualified for duty, either through the infirmity of age, or earlier, upon a medical certificate from a doctor, approved by the Committee.			
			During Disablement, not exceeding 52 weeks.		A sum not exceeding	After 5 & not exceeding 10 years membership.	After 10 & not exceeding 15 years' membership.	After 15 & not exceeding 20 years' membership.	After 20 years membership.
						£ s.	£ s.	£ s.	£
1st	Members receiving Wages of 12s. per week and upwards	4d.	12s.	£10	£5	12 10	25 0	37 10	50
2nd	Members whose wages are under 12s. per week	2d.	6s.	£5		6 5	12 10	18 15	25

The Society is managed in the same way, and by the same committee, as the Insurance Society. It has upwards of 23,500 members, with an income from all sources of £21,000, and an accumulated balance of nearly £40,000, the amount paid to members in the shape of benefits, under the various heads, during the year 1888, being upwards of £18,000.

The "London and North-Western Pension Fund," also for the benefit of the wages staff, was established as recently as 1883, and has therefore been in operation less than six years. Its object is to provide a retiring pension for members after they attain the age of 65, or for such members as, having reached the age of 60 years, are no longer able, by reason of failing health, or impaired energies, to continue at work. There are two classes of members, and a man on entering the service may elect to join either one class or the other. First-class members pay 2d. per week, to secure a pension on retirement of 10s. per week, while second-class members pay 1d. per week, and are entitled to a pension of 7s. per week. The Company contribute nearly £5,000 per annum to the fund, which is administered by the same committee as the Insurance and Provident Funds.

With a view to consolidate the two Funds, and thus enable them to be worked for the greater advantage of the members, arrangements have been made, as from the 1st January, 1889, to amalgamate the Provident Society with the Pension Fund. New members entering the combined society, who were not previously members of the former Provident Society or Pension Fund, upon attaining the pension age will not, on leaving the service, be entitled to receive a retiring gratuity, but will in lieu thereof be allowed an increased pension of 2s. per week. To those who were members of the former societies it will be optional whether they take the retiring gratuity or the increase of pension.

It has been thought that the case of the men employed in the locomotive department differs in some degree from that of the men engaged in the traffic and permanent way departments, seeing that amongst a body of men who are continually coming and going, and constitute, in fact, a sort of floating population, no scheme which provides for a large surplus or reserve fund would be equitable, and therefore the following plan has been adopted :—

A society has been formed, or rather two societies—one for Crewe works and one for the engine drivers, firemen, and others comprising what is known as the "running department." These societies are managed by delegates elected by the members, assisted by representatives of the Company; and there is a scale of benefits ranging, according to the grade of the men, from £40 to £100 in the case of death or permanent disablement from accident on duty, with a weekly allowance in case of temporary disablement from any cause, and a payment in the event of death from natural causes. The expenses are met by calls upon the members from time to time throughout the year, as necessity arises, but averaging from five to ten calls per annum ranging from 4d. to 1s. per call, according to the men's pay, the Company supplementing these payments by liberal contributions. The number of men in these two societies amounts to upwards of 15,000.

By means of these twin societies, the men employed in that most important branch of the railway service, the Locomotive Department, are enabled, at an expense to themselves so small as hardly to be felt, to make a substantial provision against the results of illness and of death, either from accident arising in the discharge of their duties, or from natural causes.

CHAPTER IV.

PERMANENT WAY.

WE have had occasion to remark in a former chapter that the permanent way of a first-class English railway of the present day represents a very advanced stage of development as compared with the rude methods of construction of the earlier railways, and perhaps this fact can most forcibly be illustrated bya brief retrospect of the various changes and improvements which have from time to time been introduced, and which have finally resulted in giving us the magnificent steel track of the present age, upon which a train weighing, with its engine, nearly 300 tons may travel with ease and safety at a speed of from fifty to sixty miles an hour.

As we have already seen (Chap. I.), the earliest conception of a railway or tramway found its embodiment in a wooden track consisting of oak rails laid upon blocks of wood about two feet apart, and upon which carts with flanged wheels were drawn. Tramways of this description are said to have existed in the neighbourhood of Newcastle-on-Tyne more than two hundred years ago. Nicholas Wood, in his "Treatise on Railroads," published in 1825, gives the Coalbrookdale Iron Works Company the credit of being the first to construct cast-iron rails, which they are said to have done in 1767, the rails being 5 feet long,

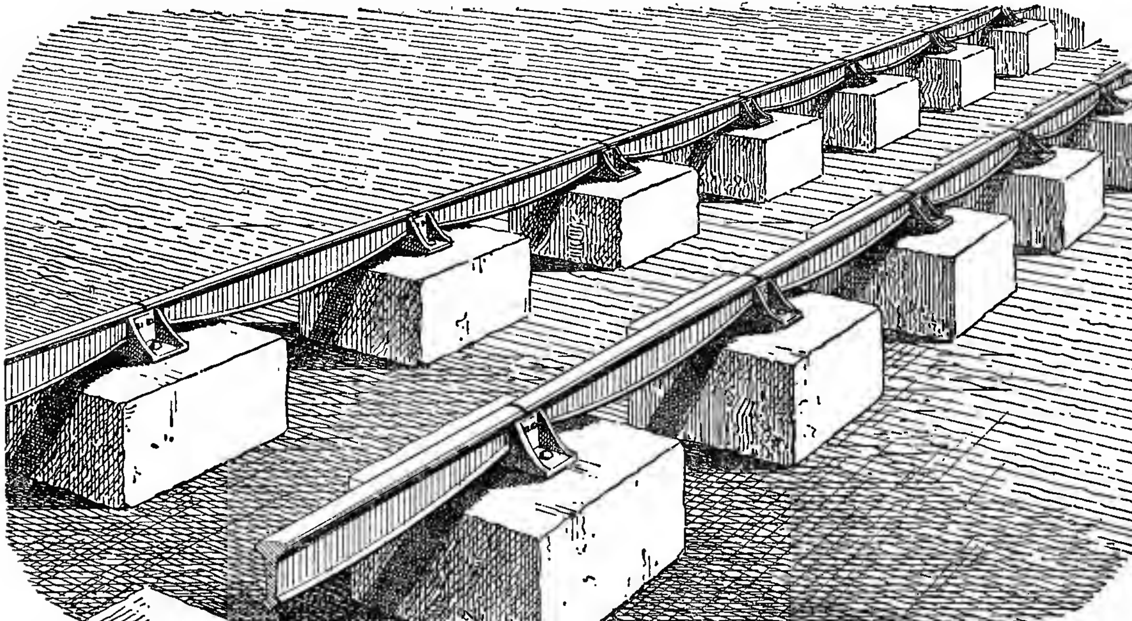


FIG. 2.

RAILWAY WITH "FISH-BELLIED" CAST-IRON RAILS LAID ON STONE BLOCKS—CONSTRUCTED AT LOUGHBOROUGH IN 1789.

4 inches wide, and 1¼ inch thick, with three holes drilled in them, by means of which they were fastened to oak rails, these latter being in turn laid upon sleepers.

In 1776 we find in use, at the Sheffield Colliery, cast-iron rails of an angular section (Fig. 1), laid upon wooden sleepers, and which required no flanges to the wheels. Tramways constructed in this manner exist, and are in use in some parts of the country at the present time.

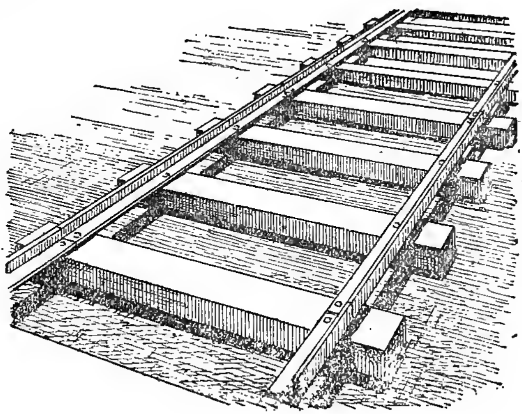


FIG. 1.
SHEFFIELD COLLIERY TRAMWAY OF 1776.

In 1789 a railroad or tramway was constructed at Loughborough, having cast-iron "fish-bellied" rails, from three to four feet in length, resting on stone blocks instead of wooden sleepers, and requiring flanged wheels (Fig. 2).

The first malleable iron rail was patented by J. Birkenshaw, in 1820, and this form of permanent way,

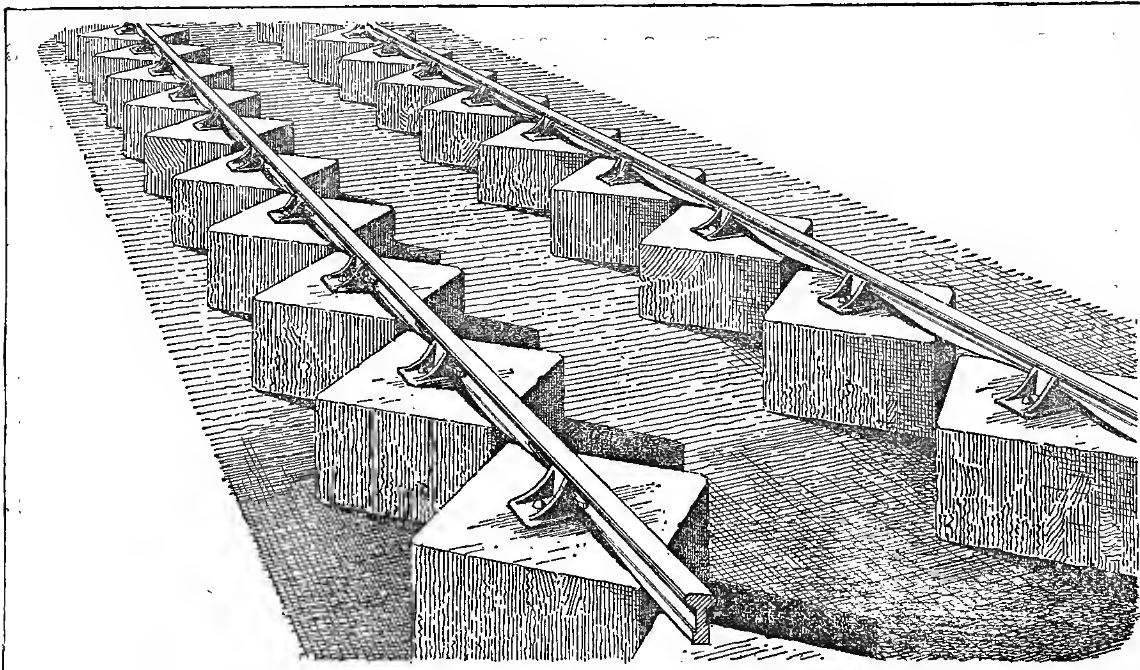


FIG. 3.
PERMANENT WAY OF LIVERPOOL AND MANCHESTER RAILWAY, 1830.

with rails weighing 28 lbs. per lineal yard, was used on the Stockton and Darlington Railway, and was subsequently adopted by George Stephenson when he constructed the Liverpool and Manchester Railway; but he increased the weight of the rails to 35 lbs. per lineal yard, their length being 15 feet. The rails rested for the most part on solid stone blocks, laid diamond fashion, but on embankments and on peaty ground oak sleepers were used (Fig. 3).

These rails, as will be seen from the illustration, were of the "fish-bellied" pattern, but in practice, and as the demand increased, these were found troublesome to roll, and this difficulty led to the introduction of the flat-bottomed or "flat-footed" section of rail, combining a solid head with a flanged base. This is known as the "Vignoles" rail (Fig. 4, No. 4), and, although still largely used in the colonies and abroad, it is very little in use in this country except in the case of lines laid down for temporary use by contractors.

Another form of rail, known as the "Bridge" rail (Fig. 4, No. 3), was introduced by Brunel contemporaneously with the "Vignoles" rail, and this section of rail, laid upon longitudinal instead of transverse sleepers, was adopted as the standard form of permanent way on the Great Western Railway.

In 1837 the double and equal-headed reversible rail, as shown by Fig. 4, No. 5, weighing 84 lbs. per lineal yard, was originated by Joseph Locke, and was adopted on the Grand Junction Railway. It was originally intended, when one head was worn out, to turn the rail and use the other, but it was found in practice that, unless the rail was turned very frequently, the lower head became indented, where

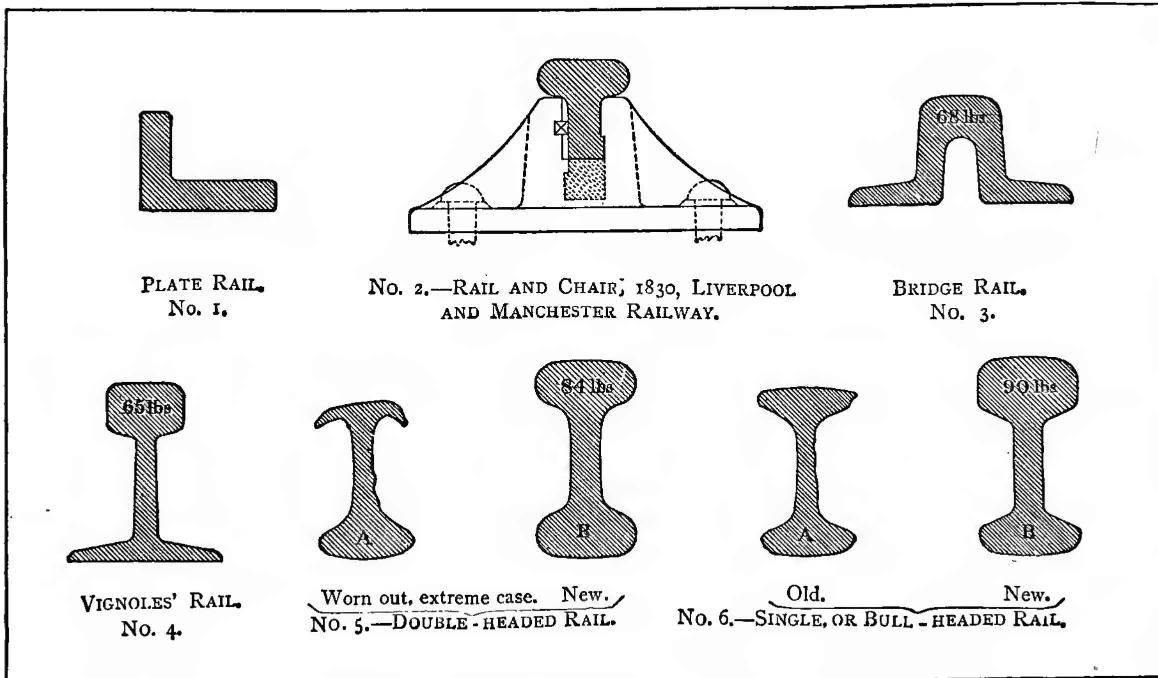
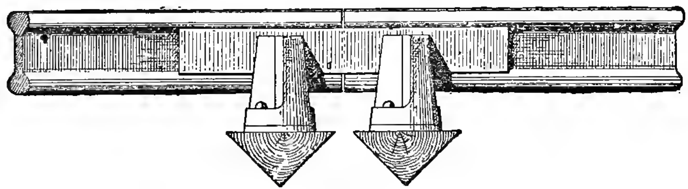

68 lbs
65 lbs
A
84 lbs
B
A
90 lbs
B
PLATE RAIL.
No. 1.
No. 2.—RAIL AND CHAIR, 1830, LIVERPOOL AND MANCHESTER RAILWAY.
BRIDGE RAIL.
No. 3.
VIGNOLES' RAIL.
No. 4.
Worn out, extreme case.
New.
No. 5.—DOUBLE-HEADED RAIL.
Old.
New.
No. 6.—SINGLE, OR BULL-HEADED RAIL.

FIG. 4.

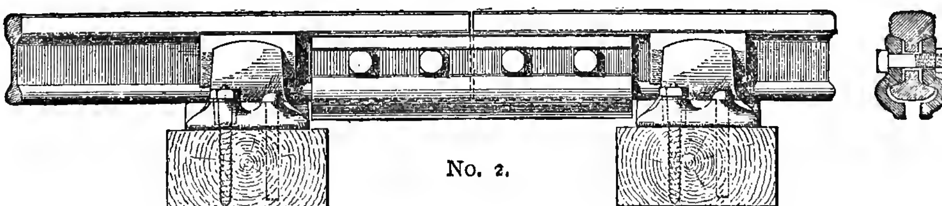
it rested in the chairs, to an extent which rendered it unfit for a running surface. This section of rail is still in use on some of the railways in this country, but it is being rapidly superseded by the "bull-headed" section (Fig 4, No. 6), which is simply a refined and enlarged copy of George Stephenson's single-headed rail, and was used in very nearly its present form on the Shropshire Union Railway some forty years ago.

Up to the year 1847 the ends of the rails rested in joint chairs, but in that year Mr. Bridges Adams introduced the suspended joint with fish-plates (Fig. 5, No. 1), by which a much greater degree of elasticity was imparted to the permanent way. The innovation was not adopted upon the London and North-Western Railway until the year 1853, but although, since then, many other plans have received a trial, and some hundreds of patents have been taken out, this form of connecting the rails is found to be the most simple and effectual, and, with one improvement, which is shown by Fig. 5 No. 2, is still used universally on the London and North-Western Railway.

Rails have gradually increased in length, in depth, and in sectional area, but perhaps the greatest improvement which has been effected in them is in the change of material from malleable iron to Bessemer steel. Steel is not only found to be more homogeneous, generally wearing uniformly from end to end, but its strength is half as great again as that of iron, and the rail may thus be reduced in weight by abrasion and corrosion to an extent that would be unsafe in an iron rail. On the other hand, it is only fair to add that steel corrodes more rapidly than iron (in the proportion of about five to four), and in tunnels, and in manufacturing districts



No. 1.



No. 2.

FIG. 5

where sulphurous and other acid gases are present in the atmosphere, the life of the rail is shortened to a material extent. On the whole, however, the balance of advantages is greatly in favour of steel.

Fig. 4, No. 5 (A), shows the section of a double-headed rail which has been in use for twenty years in the main line at a large station, and subsequently for five years in a siding, and one head of which is quite worn out This is, of course, an extreme case, but it very forcibly indicates the possible reduction of sectional area in a rail constructed of first-class material. On the other hand, Fig. 4, No. 6, shows the section of a rail which is no longer fit for the main line, but might still be used in a siding; in both these cases it will be observed that corrosion has more or less had the effect of reducing the portion of the rail not in contact with the wheels, and that the original shape of the head of the rail is no longer recognisable, so great is its reduction and deformation under the heavy percussive and abrading forces to which it has been subjected.

The improved form of permanent way actually in use upon the London and North-Western Railway at the present time is seen in Fig. 6. It consists of wooden sleepers, laid transversely, and which are of well-seasoned Baltic timber, into which creosote oil has been forced under pressure to the extent of $3\frac{3}{4}$ gallons to each sleeper. The sleeper, which is 9 feet in length, 10 inches wide, and 5 inches deep, when creosoted, weighs 150 to 160 lbs. To each sleeper two cast-iron chairs, each weighing 45 lbs., are secured by two iron spikes and two galvanised iron screws, a layer of hair felt being interposed between the sleeper and the chair. The spikes are cup-headed, slightly tapered, 6 inches

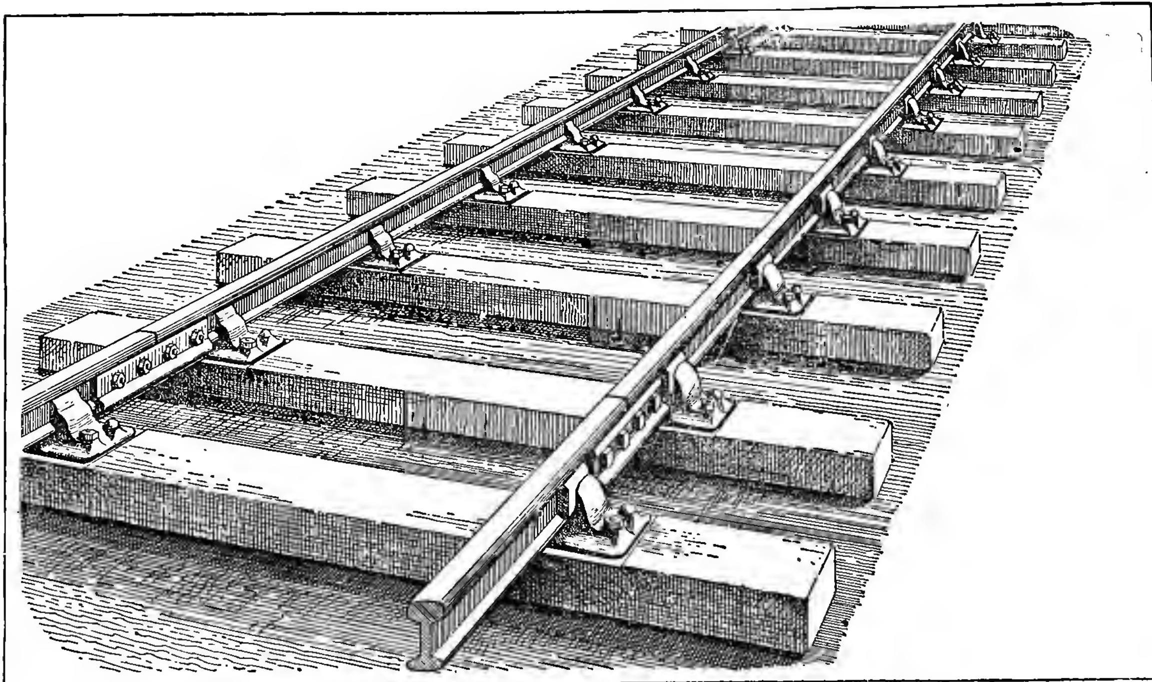


FIG. 6.
PERMANENT WAY OF THE LONDON AND NORTH-WESTERN RAILWAY, 1888.

in length, and weigh 19 oz. each. The screws have a hexagonal head, are also slightly tapered, and weigh 20 oz. each, their length being $6\frac{3}{4}$ inches. A creosoted oak ferule or socket is inserted in each hole in the chair, through which the screws are driven, so as to obtain a mechanical fit by simple means. The steel rails, which are laid in the chairs, are of the single-headed section, 30 feet in length, and weigh 900 lbs., or 90 lbs. per lineal yard. It may be mentioned that over bridges, and for some other special purposes, about 10 miles of rails have been laid upon the London and North-Western Railway which are 60 feet in length.

Each 30 feet rail rests on ten sleepers, and is secured in its place by creosoted oak keys 6 inches long, $3\frac{3}{8}$ inches wide, and $2\frac{1}{8}$ inches thick, driven between the rail and the chair, outside the rail. The fish-plates by which the rails are joined (Fig. 5, No. 2) are 20 inches in length, $5\frac{1}{4}$ inches deep, and weigh 54 lbs. per pair. The four bolts by which they are secured to the rails are square-headed, with a Whitworth thread 9 to the inch, the nuts being hexagonal.

A certain number of iron and steel sleepers have been laid down on the London and North-Western Railway experimentally, the first step in this direction having been taken eight years ago. The results have been varied, a percentage of the sleepers having failed, while, on the other hand, a larger percentage appear to be standing well; but, on the whole, a sufficient time has not yet elapsed to fairly test their durability.

Permanent way engineers insist that the first and last requisite for the maintenance of a sound and good permanent way is a perfect system of drainage. The formation requires to be kept as dry as possible, and to this end, if the material is of a porous nature, retentive of moisture, it should be well drained by means of rubble or pipe drains; if it is not of a porous character, as, for instance, stiff clay or rock, the surface should be formed with a section similar to that of a well-constructed macadamized road, so as to throw the water quickly off its surface to the side ditches. Upon such a formation should be placed a layer of bottom ballast of uniform size and durable quality, free from dirt or any substance which absorbs and retains moisture. Upon the bottom ballast the sleepers will be laid, and with a sufficient quantity of top ballast, which should be equally clean and durable, although, preferably, of smaller size, the line will be raised and adjusted to its intended level, the plate-layers, in laying the sleepers, taking particular care to obtain a uniformly solid and level bed for each sleeper, so that it may take precisely its proper share—no more and no less—of the weight of the passing trains. Skill and attention displayed at this stage meet with their due reward, and much subsequent trouble and anxiety is saved to the permanent way inspector, who has a length of road to maintain, if he takes care that his sleepers are not bedded on irregularly-sized lumps of stone, that his chairs are fixed to a uniform gauge, and that the sleepers are placed at right angles to the direction of the line, and well packed, or beaten up, as firmly under one rail as the other. He should see that his rails are not bent in unloading, that all crooked or defective fish-plates, spikes, and screws are rejected; that his curves are of uniform curvature, and with super-elevation proportioned to the radii, and that many other apparently insignificant precautions are not neglected, all of which contribute to the construction of a sound and perfect permanent way over which

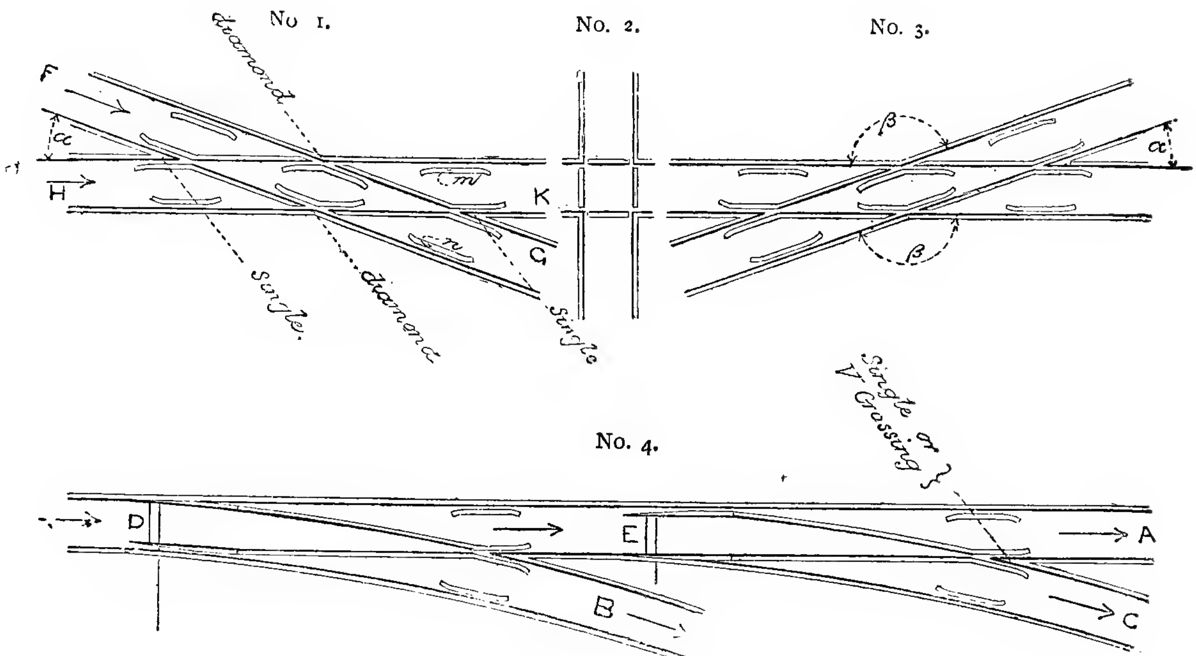

No 1.
No. 2.
No. 3.
No. 4.
diamond
diamond
Single.
Single
F
H
K
G
m
n
α
β
Single or
V Crossing
A
B
C
D
E

FIG. 7.

heavy trains may travel safely and smoothly at a high rate of speed, and with a minimum wear and tear and expenditure of motive power.

The intersection of one rail with another at any angle is termed a "crossing," and these crossings are so constructed with wing rails and check rails as to guide the flange of the wheel, and ensure its taking the required direction at the point of intersection. The simpiest form of crossing is where the rails intersect each other at right angles (Fig. 7, No. 2), but such crossings are of rare occurrence. When the rails intersect at any other than a right angle, the crossings are of two types. When the external angle of intersection is acute (as at *a*, Fig. 7, Nos. 1 and 3), the crossing is known as a single or "V" crossing, but where the angle of intersection is obtuse (as at B, No. 3), it is called a "diamond" crossing. "Diamond" crossings occur only in pairs.

For "V" crossings, check rails are provided (*m* and *n*, No. 1, Fig. 7), which, by holding one wheel on an axle to its proper course, prevents the wheel at the other end of the axle from taking the wrong side of the point of the crossing between *m* and *n*. The check rail *n* guides the flange when a wheel is travelling from F to G, and the check rail *m* guides it in the direction H to K.

From an inspection of these diagrams (Fig. 7) it will be easy to trace the course of the wheel flange, which is always on the *inner* side of the wheel.

To turn a train off one line of railway and on to another which connects with it, a pair of tapered moveable rails, called "switches," or "points," are made use of (see Fig. 7, No. 4). These are connected by rods with a lever in the signal cabin, and worked by

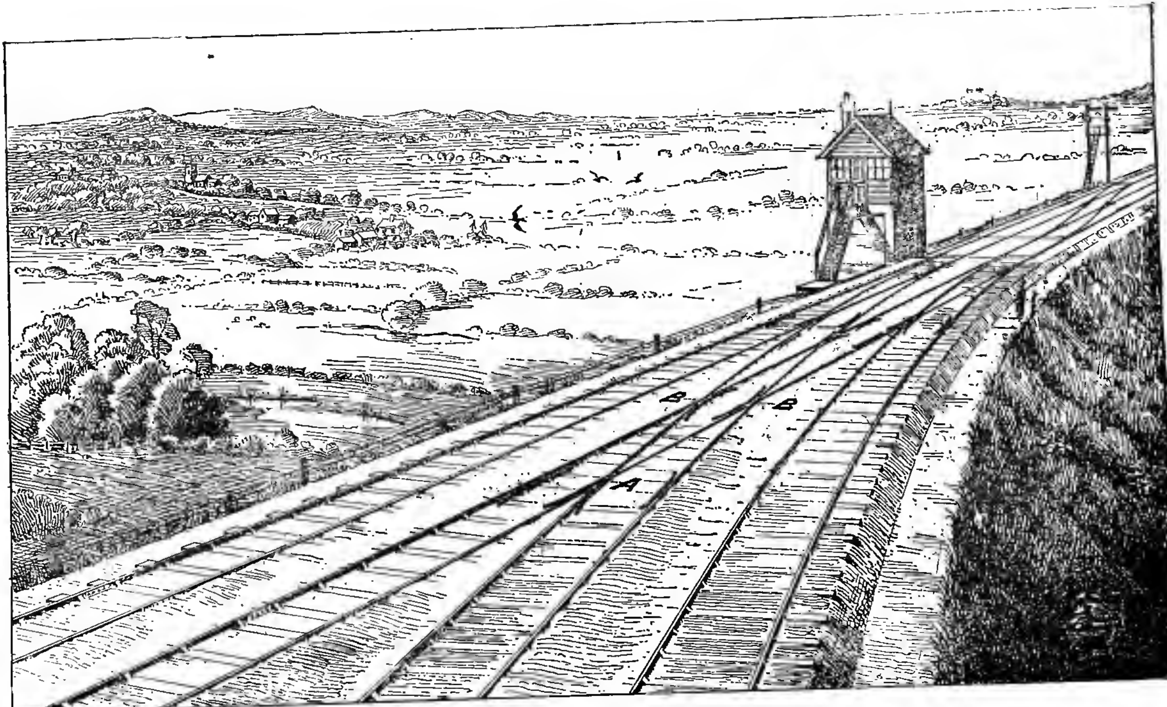


FIG. 8.—JUNCTION.

the signalman ; the lever being so controlled mechanically that it is impossible for the signalman to lower the signals for a train travelling in the direction of the arrow on line "B," until the "points" or "switches" have been placed in their proper position, as at D. On the other hand, before the signal can be lowered for the line C the switches must be placed as at E.

Fig. 9 gives a view in perspective of a pair of switches, and shows the manner in which they are worked.

Fig. 8 is a view of an ordinary junction between a main line and a double branch line, with the signal cabin from which the points and signals are worked, and the home signals for the junction. The diamond crossings are marked B, and the nearest single crossing is marked A. This is a simple double junction ; but where the running lines are duplicated, and there are numerous cross-over-roads and sidings connecting with the main lines, the arrangement of roads frequently becomes extremely complicated.

There is one important feature in the formation of a well-constructed permanent way, which is known as the super-elevation of the outer rail on curves. Any one who has witnessed the evolutions of a circus rider will have observed that both horse and rider, in order to maintain their balance, incline their bodies towards the centre of the ring, and the greater the speed, the greater is their deviation from the perpendicular. In order to enable a train to do by mechanical means what the rider does by muscular power—that is, to balance the centrifugal force of a train running round a curve—it is necessary for the outer rail on a curve to be raised somewhat above the inner rail, and the

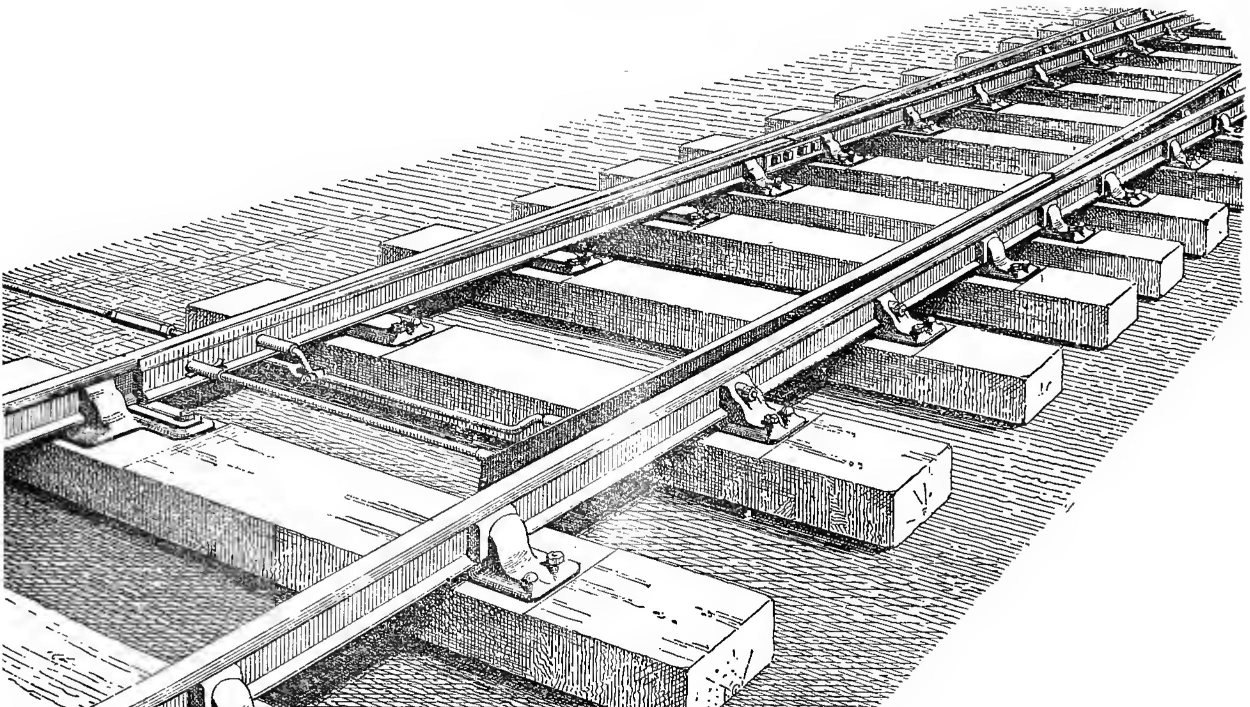


FIG. 9.—VIEW IN PERSPECTIVE OF A PAIR OF SWITCHES SHOWING THE M...

smaller the radius—that is the sharper the curve—and the higher the speed of the trains, the greater must be the super-elevation. In practice it must be adjusted to the average speed of the fastest trains that are likely to run over it—that is, the express passenger trains.

Railway curves are invariably arcs of circles of greater or less radius, except for a short length, where they join or leave the straight line. Where the radius of the curve is uniform, a uniform super-elevation is given to the outer rail, but this elevation dies away gradually to the straight line, where the rails become level. As the super-elevation decreases the radius of the curve increases until it becomes infinite, or, in other words, until the straight line is reached.

If it be asked what is the steepest gradient a railway should have, the answer is, "The best that can be obtained under all the circumstances; or, in other words, the nearest to a dead level." There are cases in which the physical conditions of a country will only permit of a railway being constructed with sharp curves and steep gradients, except at a practically prohibitive cost. It is, nevertheless, a fact that the less the deviation from a straight line and moderate gradients, the greater is the safety and economy of working; and, in constructing a main line of railway, it is frequently worth while to incur heavy outlay at the outset rather than handicap the undertaking with difficulties of working, which will place it at a disadvantage in competing with other railways for the same class of traffic, for which punctuality and speed are of the first importance.

In practice it is usually found that sharp and frequent curves are associated with steep gradients, and, upon railways which have to be constructed in this manner, the trains must necessarily be lighter, and the average speed must be considerably less than where the conditions are more favourable. Such lines are, therefore, in proportion to the traffic carried over them, more expensive to work and maintain, but as the weight of the train, the class of locomotive used, and all the other arrangements for conducting the business are specially adapted to the circumstances, such a line as this probably involves less trouble and anxiety in working than a railway which is generally level, but which has one or more long and steep gradients in its course. In the latter case, the steep gradient is the exception, and not the rule; all the conditions are adapted to the maintenance of the high rate of speed expected with heavy trains on fair gradients, and yet the engines must have sufficient adhesion and steaming power to surmount the difficulties of the exceptional gradient. In some cases the plan is adopted of attaching an auxiliary engine (called a "bank engine") to the rear of the train at the foot of the incline, but this involves an additional stoppage and the loss of valuable time, and special precautions are required to enable the operation to be performed with certainty and safety.

The extent to which the average speed of trains is affected by the mode of construction of a railway is strikingly illustrated by the following table, which gives particulars of the curves and gradients, and the speed of the trains, upon the main line of the London and North-Western Railway from London to Carlisle, upon the Buxton Branch, the Central Wales line, and the Merthyr, Tredegar, and Abergavenny Branch.

TABLE OF GRADIENTS.

Line.	Length of Line.	Curves.					Gradients.				Average Speed. Miles per hour	Number of Stops.
		Less than 20 chains radius.	Between 20 & 40 chains radius.	Between 40 & 80 chains radius.	Over 80 chains radius.	Straight Line.	Percentage of Level Line.	Steepest Gradient.		Average Gradient both ways.		
								Rising.	Falling.			
Main Line.	Miles.	Percent.	Percent	Percent.	Percent.	Percent.	Percent.					
London and Crewe ...	158	...	...	13	39	48	9	1 in 300	1 in 177	1 in 432	48½	3
Crewe and Carlisle	141	...	5	18	27	50	13	1 in 75	1 in 95	1 in 225	48½	2
Buxton Branch	19	2	34	32	...	32	11	1 in 58	1 in 66	1 in 78	36	2
Central Wales Line... ...	59	3	35	16	4	42	11	1 in 60	1 in 60	1 in 97	31	7
Merthyr Tredegar and Abergavenny ...	19	36	13	2	...	49	5	1 in 38	1 in 35	1 in 44	22	3

It will be observed from this table that upon the Merthyr, Tredegar and Abergavenny Branch, with its steep gradients and severe curves, the trains can only run at less than half the average speed that can, without difficulty, be maintained upon the main line, and it may be added that, while upon the main line the load drawn by a goods engine is five tons to every ton of engine, on the Merthyr Branch the load is only three tons to every ton of engine, notwithstanding the low rate of speed.

The following may be mentioned as instances of specially steep gradients for short distances:—The incline to the Fruit Market at Edge Hill, near Liverpool, is 1 in 24 for 173 lineal yards, and the load which can be drawn up it is only 2½ times the weight of the engine. On the Hopton incline, on the Cromford and High Peak Railway, there is a gradient of 1 in 14 for a length of 440 lineal yards, and on this an engine is only able to draw its own weight of load.

On the other hand, on an easy gradient, a coal engine will draw from eight to ten times its own weight, and between London and Carlisle 2½ tons of passenger train load can be drawn for every ton of engine at an average speed of from 45 to 50 miles an hour, and if this is compared with the same load conveyed over the Merthyr, Tredegar and Abergavenny Branch at a speed of only 22 miles an hour, the effect of curves and steep gradients upon the working of a railway will be seen at a glance.

Sharp and reverse curves add to the train resistance and increase the risks attending a high rate of speed, and they also largely contribute to the fatigue experienced by a passenger after a long railway journey.

To maintain the permanent way of a great passenger railway in perfect working order, a very careful and complete system of organisation becomes necessary, and this, upon the London and North-Western, is carried out in the following manner :—

Three men, with a foreman or ganger, form a gang, and have charge of the constant inspection and maintenance of about two miles of double line of railway, being an average of one man to each mile of single line; but the exact number depends upon the extent of the traffic using the line, and the consequent wear and tear, and the number of junctions and sidings which have to be maintained. Every ten or twenty of these gangs are under the direct supervision of an inspector, who thus has a district of from 20 to 40 miles of railway. Every seven or eight of these inspectors are under the control of a chief inspector, who is therefore responsible for from 200 to 250 miles of railway, and who has also under him travelling gangs of ballasting men and re-layers, who are employed in renewing the permanent way and carrying out alterations and additions. Each length has also a full complement of artificers, joiners, masons, bricklayers, painters, blacksmiths, etc., with their foremen and inspectors, and these men repair bridges, tunnels, stations, and all kinds of buildings which constitute the "works" of a railway. All these men, together with the Chief Permanent Way Inspector, and the men under him, are under the direction of a civil engineer of experience, who has also a staff of surveyors, draughtsmen, and clerks, with offices and workshops at the most important centre of traffic in his district. Such a section of the railway is called a "Division," and there are eight such divisions on the North-Western Railway, the eight divisional engineers being responsible to an "assistant engineer" who, together with another assistant engineer of equal rank who has charge of the construction of new railways and other important contract works, acts under the instructions of the engineer-in-chief of the Company.

The duties of the gangers comprise the daily inspection of every portion of the section of line under their charge, and the repairs of the permanent way, fences, drains, and roads. They have also to report anything they may observe to be amiss with the telegraph wires, the signals, or with passing trains more especially during storms, fogs, or heavy falls of snow. They furnish their inspectors with an account of all materials required and used, and are responsible for the work performed by the men under them, which is of a very miscellaneous character.

The inspectors of permanent way are responsible for the discipline of their men, and for keeping a correct account of the time they work, and the wages paid to them. It is their duty also to keep a record of all materials received and used, to see that every care is taken of the property of the Company, and to report to the chief inspector of the district, or to the divisional engineer, every circumstance of an unusual character which may come within their knowledge. They take charge of the renewals of permanent way, and of the operations necessary in case of floods, and of landslips of an ordinary character. In mining districts they keep careful watch, and see that the railway is lifted and maintained when subsidences occur; they daily visit portions of their districts, and are in constant personal communication with their gangers, acquainting them with all instructions issued from headquarters.

The chief inspectors of districts are responsible for the general condition of the main lines, and it is their special duty to see that a uniform standard of maintenance is kept up by each of their sub-inspectors, and that orders given by the engineer are duly observed and consistently followed out. They arrange the running of trains of materials, and provide for ballasting operations, and are in constant communication with the divisional engineers, to whom they report upon every matter affecting the permanent way.

A similar chain of supervision exists in the workshops in each district.

Periodical meetings of the divisional engineers are held, at which the various points which arise from time to time in connection with the maintenance and repair of the permanent way are discussed, and the engineers are thus enabled to compare notes and give each other the benefit of their respective experience.

The stability of the permanent way and works of a great railway is frequently threatened, and ceaseless vigilance has to be exercised to avert the dangers arising from circumstances which no human foresight can anticipate. Embankments and sea-walls are sometimes demolished by storms; landslips and the fall of rock from overhanging cliffs may cover the rails; sudden subsidences of the surface, due to mining operations, may take place; bridges and viaducts may be set on fire, or washed away by floods; dangerous compounds explode in transit, rails be torn up by collisions, or portions of tunnels may collapse. Instances of mishaps from all these causes have occurred in actual experience, and to repair the damage and restore the communication in the shortest possible time is the task which frequently has to be undertaken by the railway engineer, occurrences of the nature referred to frequently happening without the least previous warning. In such cases, the first difficulty the engineer experiences is very often in ascertaining, with any degree of accuracy, what has actually taken place, and the precise extent of the damage which has resulted, and he has next to determine what, with the time and means at his disposal, he is justified in attempting. It is often found that men, plant, and material can be more expeditiously obtained from some central depôt than from local resources, although the depôt may be a hundred miles or more from the scene of operations.

A notable illustration of what can be done in this way in an emergency by a company like the London and North-Western, possessing great resources, occurred when, in the great storm of Sunday, the 17th August, 1879, the Llandulas viaduct, on the main line of the Chester and Holyhead Railway, was undermined by flood, and washed completely away, interrupting, for the time being, the traffic between England and Ireland. For two days, until the flood subsided, nothing could be done, but within the space of five days afterwards the railway was deviated for about half-a-mile so as to strike the river at the narrowest point, and a temporary trestle bridge was erected, over which the first train passed at 2 p.m. on the 24th August, exactly seven days after the mishap occurred. The line was cut in the slope of the embankment leading to the old viaduct, and was everywhere placed upon solid ground, or upon stacks of old sleepers, so that there might be no settlement, and the line might be fit for the heaviest traffic immediately it was completed. The gradients were 1 in 23, dipping down to the river, and rising on the opposite side, and everything was finished off in the most substantial and careful manner; but of course great skill and attention were necessary on the part of the engine drivers, and the difficulty of working long and heavy trains, some of which required three engines, over these severe and changing gradients, without breaking the couplings, or heavily bumping the carriages together, can hardly be exaggerated, yet no mishap occurred, and the passengers in the trains were scarcely aware that they were travelling under unusual conditions.

The new permanent viaduct was meanwhile rapidly constructed, and was actually completed and opened for traffic on the 14th September, less than one month after the mishap. Its length is 224 feet, divided into seven spans of thirty-two feet each, and its height is fifty feet. Forty-two girders, each thirty-two feet in length, were required, and the plates and angles for each girder were rolled in one length. All these were made in the Company's own steel works at Crewe, and the whole of the material was turned out and ready for erection within seven days, the steel having been manufactured, rolled, and worked, within that short space of time.

CHAPTER V.

SIGNALS AND INTERLOCKING.

AN attempt will now be made to give some idea of the elaborate system of signalling the trains, which, in conjunction with the use of the electric telegraph, alone enables the traffic of a great railway to be carried on with safety and despatch, and which has grown up from the rudest beginnings side by side with the growth of the railway system itself.

There is, of course, a very obvious and primary necessity, on any railway, for some visible indication by means of which the drivers of the trains may be warned when they may proceed, and when they must come to a stand, and shortly after the opening of the Stockton and Darlington, which was the earliest railway constructed, one of the station masters is said to have adopted the simple expedient of placing a lighted candle in the window of the station-house when it was necessary for a train to stop. From this rude beginning to the complicated system of signals and interlocking which may be seen, for example, at Clapham Junction or Waterloo is a very long step in advance, and it has, of course, only been achieved by a gradual process of evolution. Thus when the Liverpool and Manchester Railway was first opened in 1830, the only arrangement made for signalling the trains was a flag by day or a lamp by night, held in the hand of the pointsman, as he was then called, and an old print from the "Illustrated London News" shows us the pointsman, or policeman, in the long-tailed coat and tall hat of the period, standing outside his hut, and making the prescribed motions with his flag; but this simple device was soon found to be insufficient, and, about four years after the line had been opened, stout posts were provided, upon which lamps were placed by the pointsman. This really marks the first step in the creation of the present system of signalling; but about the same time the Grand Junction Railway was approaching completion, and the necessity for some improved form of fixed signal seems to have been realised, since we find that the line, at its opening in 1837, was provided with station signals in the form of discs, carried on poles about 12 feet in height, with a lamp at the top, the disc and lamp being arranged to turn through a quarter circle by the pointsman actuating a lever at the base. If the disc was turned so as to face an approaching train, or the lamp showed a red light, it implied a signal to stop; while, if the disc was turned edgeways to the driver, or the lamp showed a white light, it meant "go on." These signals, which may still be seen in use in some remote country districts, were fixed on the platforms at stations, or outside the pointsmen's huts at junctions, and corresponded in position with the home signals of to-day, the "distant signal" being, at that time, a thing unknown.

Some five years later, about 1842, a semaphore signal, somewhat similar to those in use at the present time, was introduced, and it appears probable that this now universally-adopted type of signal very rapidly superseded the disc signals of the earlier period. The old semaphores showed three positions, "all right," "slacken speed," and "danger," the arms being actuated by the pointsman by means of a lever on the post. Up to this time, although the necessity must have existed, as it does to-day, for a driver to be warned as to the state of the line some time before actually reaching the point of obstruction, where he was required to stop, no attempt seems to have been made to meet the want; but at length accident proved once more the parent of design, for in the year 1846 a pointsman, who had to attend to two station signals, placed some little distance apart, in order to save himself the trouble of walking to and fro between them, procured some wire, which he attached to the levers of the signals, using a broken iron chair as a counter-weight, and by this simple expedient found himself able to work both signals without leaving his hut. Thus was demonstrated the possibility of working a signal at a distance, and this man's primitive contrivance doubtless hastened the introduction of distant signals, the use of which rapidly became universal. "Starting signals" were the development of a later period, the necessity for them having only been brought about by the application of the Block-Telegraph system some years after.

The next step in advance was the adoption, in a very elementary form, of the principle of interlocking, and this seems to have been forced upon the attention of railway engineers at a very early period, since, as early as 1843, we find that the levers for working the signals at a junction were provided with a simple mechanical device to prevent the main-line signal being lowered at the same time as that for the branch line; but, at that time, no attempt was made to extend the locking to the levers which actuated the points. In the following year Mr. C. F. Whitworth patented a scheme for locking points and signals on the ground by means of locks worked by wire, but there was no suggestion for *concentrating* the levers. The apparatus was complicated and difficult to work, and apparently it was never brought to bear, but there is no doubt that the proposal contained the germ of the interlocking system as we have it to-day.

In 1856 a successful attempt was made by Mr. John Saxby, at the Bricklayers' Arms Junction (London), to concentrate and interlock the levers working both points and signals, and although the apparatus employed was crude as compared with the perfect mechanism now in use, it represented the earliest practical application of the principle of interlocking. In 1859 the first interlocking frame was fixed on the London and North Western Railway, at Willesden Junction, by Mr. Austin Chambers, who patented his arrangement in 1860, and from this point the interlocking of the London and North Western system proceeded rapidly; for thirteen years later, in 1873, it is recorded that 13,000 interlocked levers were in use on that railway.

At this point it may be worth while briefly to describe the meaning and application of the different kinds of signals and locking appliances in use upon the principal railways at the present time.

The form of signal most generally adopted is the "Semaphore," which is no doubt familiar to most of my readers, and consists of a timber or iron pole varying in dimensions according to circumstances, but sometimes as much as 70 feet high, with an arm about 5 feet long, capable of assuming two positions when actuated by mechanical force. When this arm is horizontal and at right angles to the post it signifies "stop"; when it is nearly vertical it indicates "go on." As the arm cannot be seen at night, a lamp is provided on the post, and working with the arm is a frame containing coloured glasses, and termed "spectacles," which cause the lamp to show a red light to indicate "stop," and a white or green light to indicate "safety," or "caution."

The signals are distinguished as "home signals," "distant signals," "starting signals," "advanced starting signals," and "disc signals." The home signal, as its name implies, is placed close to the point at which it is desired a train shall stop. The distant signal is placed at varying distances behind the home signal according to the gradient of the line and other circumstances, but on a straight and level railway it would be about 1,000 yards back, and its function is to repeat the action of the home signal, so that if the latter is at danger the driver has timely intimation of the fact, and can at once reduce the speed of his train so as to stop at the home signal. Distant signals are distinguished by a notch cut in the end of the arm. In working a Military railway it would be quite practicable to dispense with visible signals altogether and rely entirely upon the use of the telegraph; or, at all events, the two simple signals, the home and distant, as described, would probably suffice; but for the purposes of ordinary railways the introduction of the block telegraph system has necessitated the provision of starting and advanced starting signals. Starting signals are usually placed at the end of the platform at a station, and they indicate to the driver, by the lowering of the arm, when he may start his train and enter the section in advance. The advanced starting signal is usually placed about 300 yards from the cabin, in front of the starting signal, and enables a train which has passed the platform starting signal for the purpose of picking up waggons from sidings, or to clear the section in the rear, to be brought to a stand without entering the section in advance. It may be explained that all semaphore signals are fixed in such a way that on approaching them the arm appears on the *left*-hand side of the post, and this arrangement enables the same post sometimes to be used for carrying both "up" and "down" signals.

The disc signal is used to indicate to a driver whose train is in a goods siding which joins the main line when he may leave the siding and pass out on to the main line. It is really a disc of metal, with a lamp, carried on a spindle fixed near the ground, and which turns on its axis. The position of the disc by day and the colour exhibited by the lamp at night furnish the required indications as to the state of the line.

Fig. 10 shows a simple arrangement of signals at a station, and Fig. 11 shows the ordinary signals required at a simple junction where there is no complication of lines.

At a small roadside station, where there are no sidings connecting with the main line, the signals are easily worked by detached levers, placed in any convenient position; but at larger stations, where there are many signals and points to be actuated, a means of concentrating the working becomes necessary, and this is done by means of the "signal cabin," which brings us to the question of interlocking. The signal cabin contains a most complicated piece of mechanism, called the "locking

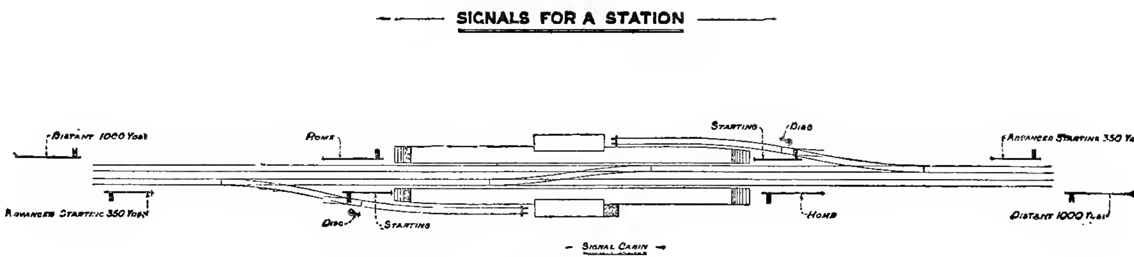


FIG. 10.

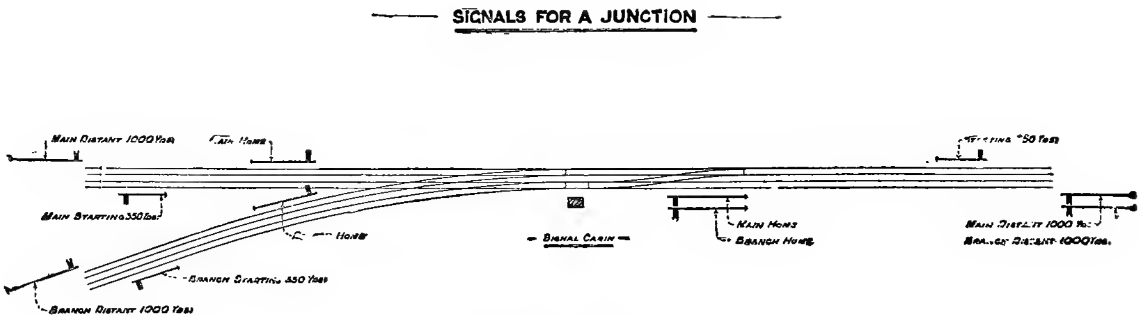


FIG. 11.—SIGNALS

frame," consisting of a row of levers by means of which the signalman actuates every pair of points and every signal under his control. By a mechanical contrivance, the points and signals are interlocked—that is to say, supposing, for example, that the signalman has moved a lever that opens a pair of points, to enable a train to come out of a siding on to the main line, the home and distant signals must be at "danger" to stop any train from approaching on the main line, and it is physically impossible for the signalman to lower them. The manner in which this is accomplished was described some years ago in the *Engineer*, and that description is so complete and lucid that probably it would be difficult to improve upon it. The writer says:—

"Mounting by an iron ladder to the signal platform, we enter the glass-house. One side of this building is occupied by a row of strong iron levers standing nearly upright from the floor, and placed at equal distances along one side of the apartment; on the opposite side are many electric telegraph instruments, and the rest of the width forms a gangway or passage from end to end for two stalwart and serious-looking men, whose time is entirely occupied in looking through the glass sides of their cell, and pulling this way or pushing that way some of the levers which are arranged before them. These levers work all the points and signals, and their number is found to correspond exactly with the number of points and signal levers outside. Every lever is numbered, and on the floor beside it there is fixed a brass plate, engraved with its name and use. Sets of them are also distinguished in a way that readily catches the eye, by being painted in strong colours. Thus, for example, all the point levers may be black, the up signals red, the down signals blue and the distant signals green. The row of levers thus presents a diversified pattern to the eye, which is readily caught by the parti-coloured groups, and, having once got the key, distinguishes quickly and correctly between their different classes.

"On examining the levers somewhat more closely, we perceive that many of them have numbers painted on their sides, not one number only, but in some cases half a dozen or more; and one naturally asks what can be their meaning. These numbers involve the whole secret of the safety which is secured by the mechanism, as will be readily understood on examining the principles on which it has been devised.

"The keys and pedals of an organ, as every one knows, command numerous valves admitting air from a wind-chest to the pipes which it is desired to sound. The key-boards are sometimes double or triple, and are occasionally arranged so that the performer sits with his back to the instrument. The pipes are generally spread over a large space, and sets of them are sometimes enclosed in separate chambers. There thus arises considerable complexity in the mechanism by which the several keys are made to operate on their respective air-valves. Nevertheless, by means of rods, cranks, and levers, such a connection is effected that, on depressing a C key, not one C pipe only, but it may be twenty C pipes are made to sound, in whatever part of the instrument those pipes may be situated. And so it is with the point and signal levers. The whole row may be considered to form a key-board, every key of which is connected by suitable cranks and rods to some one of the points and semaphores which have to be played upon. In the organ, a touch of the finger serves to depress a key, for the movement has only to admit a puff of air to certain pipes; but here the keys require a strong and steady pull, for they have to move ponderous point bars, or broad semaphore arms, and their movements have to be conveyed round many corners and over considerable distances. In both cases the mode of communicating motion is the same, the two mechanisms differing only in size and strength; and thus far the organ and the signal instrument exactly correspond. Now, however, we come to a point in which they differ *toto cœlo*. A performer on the organ can touch any keys he pleases in any order or in any number; he can 'discourse most eloquent music,' or he can rend the ears of his audience by abominable discord. Not so the signalman. Concord he can produce at will, but discord is utterly beyond his powers. He cannot open the points to one line and at the same time give a safety signal to a line which crosses it; and the points must be properly set, *close home to the stock, or fixed rail*, or the signal for a train to pass cannot possibly be given, and the least obstruction occurring to prevent the full and true opening or closing of the points is at once discovered, even with connecting rods of the greatest length practicable. Moreover, while a train is actually travelling through the points, it is itself master of the situation; not even the signalman can, either intentionally or inadvertently, change their position or disturb them until the whole train is safely passed. When he gives a clear signal for a main line, he cannot open a point crossing to it; when he gives a clear signal for a crossing he must show danger for all the lines which it crosses. And this is the meaning of the numbers marked on the different levers. No. 10, let us suppose, has 5, 7, and 23 marked on its side. He may pull at No. 10 as long as he pleases, but he cannot move it till Nos. 5, 7, and 23 have first been moved ; and so throughout the whole system. No signal lever can be moved to safety unless the point levers corresponding with it have first been moved, and no point levers can be moved while there stands at safety any signal lever that ought to stand at danger. Every lever is under lock and key, each being a part of the key which unlocks some of the others, and each forming a part of the lock which secures some of the others against possible movement, while each is at the same time subject to the control of all those which are related to it.

"This result, complex and difficult as it seems, is achieved by mechanism of great simplicity and beauty. Immediately under the floor of the platform, and just in front of the levers, are arranged several series of vibrating and sliding bars, somewhat like the tumblers of a lock, placed horizontally. These bars have projections here which stand in front of certain levers as obstacles to their motion, and notches there which permit certain levers to travel. Some of these have sloping faces, so that when a lever moves along them it edges them to one side, and this transverse motion being communicated to others of the series, brings the proper projections or notches in front of those other levers to which the moving lever is related. Thus by the movement of one lever some others are stopped, and some are left free, and this simple principle, carefully applied to all, combines them in a system incapable of discord."

There are several supplementary interlocking appliances now generally in use which may be briefly described. For instance, there is the "Facing-Point Lock," which is a bar of iron working in connection with facing points—that is, points by which one line diverges from another in the same direction. This bar, which is actuated by a separate lever in the cabin, works with, and securely locks, the points, and not until this has been done can the signal be lowered. The bar holds the points firmly in position, so that, even if the signal has been reversed, they cannot be moved while the train is passing over them. Then we have the "Locking Bar," somewhat similar to the facing-point lock, but actuated by the same lever that works the points. This is chiefly applied to siding points to prevent their being moved while a train is passing over them. "Detector Bars" are employed on parts of the line which cannot be seen by the signalman, to prevent the signals being lowered when the line is occupied by a train. "Detector Locks" are applied to facing points, and are worked by the wire that works the signals, and if the points should be injured or out of position the fault is at once detected, and the signal is locked at "danger."

Again, there is the "Point-rod Compensator," which automatically compensates for the expansion or contraction from heat or cold of the rods which actuate the points, and an "adjusting apparatus," which enables the signalman to adjust his signal wires without leaving his cabin, together with numerous other ingenious contrivances for working and interlocking with the signals the gates of level crossings, turn-tables, and canal drawbridges, and for many other purposes. There is, moreover, in use on some of the branch railways, a system of what is known as "Key Interlocking" for siding points, which merits a particular description, as it is both simple and effectual, and might prove valuable in the working of temporary or Military railways. By means of this system, while the large outlay required for laying down rods to work the points is avoided, all the security of interlocking is retained. A simple frame of levers is provided for working the signals, with a number of keys. If a certain siding is required to be used, the key which applies to that siding is withdrawn, and this has the effect of mechanically locking all signals for the road with which the siding connects. The key is then carried to the siding, and with it the points are unlocked, but when they are once opened the key cannot be withdrawn until they are closed and locked again, and the signals, of course, cannot be lowered until the key has been carried back and inserted in the lever frame, so that the security is complete.

During the interval between 1859, when the first interlocking apparatus was fixed on the London and North-Western Railway, and 1873, when, as before stated, considerable progress had been made towards interlocking the whole of the system, many alterations and improvements in the method, both of signalling and interlocking, had from time to time been introduced with the inevitable result that the signal plant and apparatus in use had come to be of very mixed types, causing great difficulty and unnecessary expense in maintenance and repairs.

This state of things led to the introduction of a new system altogether, with regard to signalling the railway, the organisation of which was entrusted to Mr. F. W. Webb, Mem. Inst. C.E., the Company's chief mechanical engineer. Up to this time, all signal work upon the railway had been provided and kept in repair under contract by the different firms of railway signal manufacturers, but chiefly by Messrs. Saxby & Farmer, of which firm Mr. John Saxby, before referred to as having been the inventor of the first effective system of interlocking, was an active partner. The Company now determined in future to make and keep in repair their own signals and interlocking apparatus, so as to secure not only efficiency and economy, but uniformity of pattern throughout the line. The scheme was brought to bear, and proved to be a success. The Company had already ample facilities in the locomotive works at Crewe for turning out all kinds of iron work; carpenters' and fitters' shops for making the cabins, signals, and other woodwork were added, a superintendent and a staff of artisans appointed, and the thing was done, the payment of royalties to inventors being soon dispensed with by the Company's engineers designing and patenting new systems of their own.

The signal-fitting shop at Crewe is 280 feet long, and 85 feet wide, the machine tools being driven by a fine Otto gas engine of 48 indicated horse-power. There is, of course, plenty of steam power available in the works, but the signal shop is often busy at a time when the other machinery is not working, and the gas engine is, for this reason, found to be a convenient and economical arrangement. One side of the shop is devoted to the preparation of the signal-posts, which are received from the saw-mill cut to the proper dimensions, and ready for fitting. The posts are of Baltic timber, varying in size from 9 inches to 15 inches square at the bottom end, and tapering to 6 inches square at the top, the length varying according to circumstances. About seven feet of each post, at the bottom, is left the full size of the timber from which the post is cut, and this portion is first charred in a furnace and afterwards well coated with gas tar, while upon the top of the post is placed a galvanised cast-iron cap. The arm of the signal is formed of a thin steel plate, stiffened by two corrugations running lengthways, and is riveted to a galvanised cast-iron centre, upon which is fixed an adjustable frame for the spectacle-glasses, made sufficiently heavy to counterbalance any accumulation of snow on the arm, and keep it in its "danger" position should any of the fittings fail. The arm works on a spindle squared to receive it at one end, and on the back light lever at the other end, except when the signal is electrically repeated, in which case a racked segment is substituted for the back light lever, and it is geared with a similar segment, in connection with the electrical contacts of the repeater apparatus. The spindle turns in a casting fastened to the post by four $\frac{5}{8}$-inch bolts, which also serve to secure the lamp bracket fixed at the back of the arm, this bracket being of sufficient width to form a "stop" for the arm when in its "danger position."

There are several other distinctive patterns of signals employed for special purposes, amongst them being the "disc" signals, previously mentioned, for controlling the exits from sidings, and the miniature semaphore signals placed low down on the post, which at certain busy parts of the line are used instead of a hand signal when it is necessary to call an engine cautiously past a signal at "danger," and which are termed "calling on arms."

On an average the fitting shop at Crewe turns out about nine signals per week, including composite or bracket and gantry posts, some of which have been constructed to carry as many as twenty-four signal arms.

On the other side of the shop are arranged a number of erecting frames, on which the interlocking apparatus is built up. The frame used by the Company is known as lever actuation, with horizontal and vertical bar locking. The horizontal bars are of Bessemer steel, rolled to a shallow channel section, the locking studs being squared to fit the channel and secured by riveting. The vertical bars are also of steel, notched, the notches being punched out cold. Each vertical bar is guided by a channel the length of itself, one wall of which is made deeper than the other; notches are cast in this to act as guides for the horizontal bars, these notches being faced by a special drifting machine at the rate of thirty-five notches per hour. The apparatus is characterised by great strength and simplicity, and, an unusual amount of special machine work being employed in its construction, a perfect interchangeability of parts is secured which is highly essential to economical maintenance. This is sufficiently demonstrated by the fact that, since the introduction of the present form of apparatus and methods of construction, the annual cost of maintenance has been largely reduced.

Signals are worked from the signal cabins by wires, but the points are actuated by rods. Trailing points are worked at a distance of 220 yards from the cabin, but in the case of facing points the distance is restricted by the Board of Trade to 150 yards, increased in some exceptional cases to 180 yards. At such distances as these, it is obviously of great importance to have a strong and thoroughly trustworthy means of connection between the points and the cabin, and for this purpose ordinary iron gas-piping was formerly used, but latterly it has been found that a steel channel section of rodding is far superior for the purpose, and the success attending this innovation has led to its adoption by several other railway companies. The chief advantage over gas-piping is that rods weakened by corrosion are readily detected and can be removed. Moreover, being manufactured to a standard in the works at Crewe, they are of uniform excellence, both in material and workmanship. About 6,000 yards of this rodding is turned out on an average every month, is sawn off to 18-feet lengths, and, when laid down, is jointed by means of fish-plates, secured by six ½-inch bolts, the fish-plates being rolled to a section to fit the channel of the rod, and the bolt holes drilled by a multiple drill. After being laid down, the rodding receives a coating of red lead and a second coat of red oxide paint, which gives it a smart appearance, and is found to be a good preservative.

For lighting the signal lamps at night, gas is used in the neighbourhood of large towns, where it is readily obtainable; but by far the greater number are lighted with petroleum oil, a large number of spare lamps being kept always on hand to provide for cases of failure.

The signalling of the London and North-Western Railway as it exists to-day has involved the erection of 1,400 signal cabins, containing some 30,000 levers, and of 16,000 signals. The steel rodding used to actuate the points would form a continuous rod from the Land's End to John O'Groat's, while the wires which work the signals would stretch from Liverpool to New York. The largest interlocking apparatus ever constructed in the Crewe works is that at the South Junction cabin at Rugby, which contains no less than 180 levers.

The maintenance of all this complicated array of signals and interlocking apparatus, over upwards of 1,800 miles of railway, is in itself a work of great magnitude, and one requiring the closest and most anxious attention, having regard to the consequences that might result from a single point rod breaking or getting out of gear; or from a single signal arm failing to respond to the action of the lever. For the purposes of maintenance, the entire system is divided into eleven districts, each of which is in charge of an inspector, these eleven inspectors being assisted by twenty-one sub-inspectors and foremen, and having under their orders sixty-eight chargemen and 430 workmen. The districts are subdivided into lengths, and each length is placed in charge of a "chargeman" and an assistant, who visit every signal cabin on their length once a fortnight, clean and oil the fittings of each signal and point, execute any small repairs or renewals that may be required, and which it is possible to carry out during their visit, and report to the inspector of the district any repairs or renewals which they may find to be necessary, but which they are unable to deal with upon the spot. In every signal cabin the name and private address of the chargeman who is responsible for it is posted, and it is the duty of the signalman to report to him every failure or defect that may become apparent during the intervals of his visits, sending at the same time a duplicate of the report to the inspector of the district.

In addition to this, every cabin is visited once a month by a fitter and his assistant, whose duty it is to carefully examine, clean, oil and, if necessary, repair the locking apparatus, particulars of the work done being entered in a monthly report, which is sent through the district inspector to the head office at Crewe.

Heavy repairs and renewals are executed by an extra gang, attached to each district, in charge of a responsible foreman, the most stringent rules being laid down as to the manner in which the work is to be carried out, so as to provide for the safe and uninterrupted conduct of the traffic during the time it is going on.

In order to secure uniformity in the sighting of the signals, the following rules are, as far as possible, adhered to, but these rules are always subject to modification so as to meet special circumstances such as, for instance, where bridges, trees, or other natural objects, or sharp curves, would otherwise obscure the sight of the signals.

Home Signals.—To be fixed within sight of the distant signal, and to be erected as near the signal cabin as possible, so that a driver, whose engine is standing at the signal, may be verbally communicated with, if necessary, by the signalman.

Distant Signals.—To be fixed at a uniform distance of 1,000 yards from the home signal, unless the gradient is a rising one, in which case a distance of 800 yards is considered sufficient. In special cases, a distant signal may be fixed a maximum distance of 1,200 yards from the home signal, where the circumstances admit of a sufficiently direct route for the wire connections to enable the signal to work freely.

Junction Signals.—The same rules apply to these as to home signals. They are to be fixed near the facing points to which they apply, and in no case at a greater distance from them than 200 yards, unless repeater signals or duplicate locking bars are provided.

Junction signals for protecting a junction in the trailing direction (*i.e.*, a junction formed by the connection of one line with another, not by meeting or facing points, but by trailing points) to be fixed a sufficient distance from the fouling point to afford some margin for a driver who may accidentally draw past the signal.

Junction signals are not in any case to be placed on the same post one above another, but a separate post is to be provided for each signal.

Platform Starting Signals.—These are sighted at a height of about 15 feet above rail-level, and so as to be seen by a driver the whole length of the platform. This rule, however, is not strictly applicable if the same post carries the distant or home signal for a cabin in advance, in which case the signals are sighted as home or distant signals, as the case may be.

Advanced Starting Signals.—These are to be sighted of a uniform height with platform starting signals, and are to be seen by a driver from the platform starting signal. They must not in any case be at a greater distance in advance of the cabin than 350 yards, and must be clearly in view of the signalman.

General Rules.—Bay starting and other subordinate signals are to be of a uniform height of 15 feet from rail level, and are to be provided with short arms and purple lights instead of red.

Lamps are never to be placed nearer together than 7 feet, except in the case of subordinate signals.

Signals elevated more than 45 feet above rail-level are to have a lower arm on the same post, 15 feet above rail-level, so as to be visible in fogs or thick weather.

Signal cabins are to be so placed that the signalman may have a good sight of all points and signals actuated from his cabin, more especially facing points.

All signals are to be fixed on the left-hand side of, and as near as possible to, the road to which they apply, no signal or cabin, however, being erected at a less distance than 4 feet 6 inches from a passenger line of rails.

A distant signal for a cabin in advance must never overlap a home or starting signal for a cabin in the rear, but must be fixed on the same post, 7 feet below the home or starting signal, and be controlled by the home or starting signal, to prevent the distant arm being "off" when the home or starting arm is at "danger." When a distant signal is placed below a home or starting signal, no other signal must be placed on the same post, excepting "fog" or "calling-on" arms.

When the distant signals for a junction have to be combined with the home or starting signals for a cabin in the rear, then the starting signal post must be nearest the line with the distant arm for the right-hand junction placed under it, and the distant signal for the left-hand junction must be carried by a separate post to the left of the home or starting post. Both distant arms must be controlled by the home or starting signal. This rule will not apply if the junction to the right is a goods loop or other subordinate line; in this case, the distant signal must be carried on a separate post to the right of the home or starting post.

CHAPTER VI.

TELEGRAPHS.

TELEGRAPHY might not inaptly be termed "the handmaid of steam," for it plays an important part in almost every operation connected with railway working. By its means the trains are started from the stations and conducted safely from point to point throughout their journey; the signalmen who regulate their passage are placed in an unbroken chain of communication one with the other; the nature of the train and its destination, and the fact of its punctual running, or otherwise, are flashed ahead from signal cabin to signal cabin as it speeds on its journey; while the faithful telegraph warns the signalman if his signals are not acting freely or if his lamps are not burning brightly. By telegraph the marshalling of goods waggons, the loading of trains, and the movements of empty waggons are intelligently controlled, and the whole business of the railway is carried on with a promptitude and despatch that could not otherwise be attained. In short, the uses of telegraphy as applied to railways are so numerous, and so diversified, that it would be a formidable task even to catalogue them, and one still more formidable to attempt their description in detail.

In the earlier days of railways, and before electricity had been brought to bear upon their working, the only means for providing for the safety of the line was by erecting fixed signals at certain points, and keeping them at "danger" for a specified time after the passage of one train, before another was allowed to follow. Obviously, under a system of this kind, only a very limited number of trains could be dealt with within a given period of time, and as the traffic increased and trains were multiplied it was found quite inadequate, and some better plan had to be devised. The electric telegraph had already been utilised for transmitting from station to station the times of departure of the trains, and about the year 1853 Mr. Edwin Clark introduced the absolute block telegraph system, by means of which the number of trains which may be passed over a given section of line, with perfect safety, may, by the multiplication and shortening of the sections, be said to be almost unlimited.

Mr. Clark's apparatus took the form of what is known as the "three-wire" block telegraph for double lines, and this form has held its own up to the present time—that is, there is one wire with an instrument at each end of the section for the up line, the same for the down line, and one wire for the bell circuit, the latter being common to both lines. Besides this, there is in use a "one-wire" system, also for double lines, but which shows only two positions of the indicator instead of three. The advantages claimed for the "one-wire" system are (1) that on railways where there are four lines of rails only two wires are required, instead of the six that would be needed under the "three-wire" system; and (2) that where the sections are long, the "one-wire" system is less expensive, although in sections half a mile or less in length the "three-wire" proves to be the cheaper of the two, for the reason that, although the wires cost more, the instruments cost less. In addition to these, there is a single-line block telegraph, which is worked by two wires, one for the block instrument and one for the bell.

All the different kinds of block telegraph apparatus may be worked either on the "absolute" or "permissive" system, according to the requirements of the case

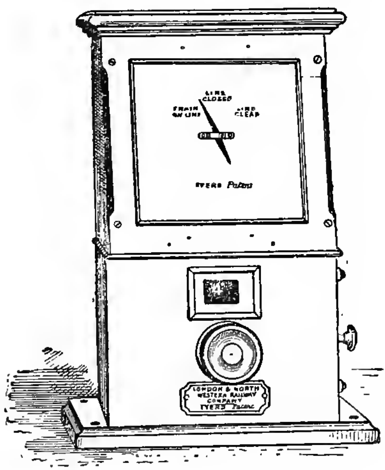


FIG. 12.
THREE-WIRE "TELL-TALE" BLOCK TELEGRAPH INSTRUMENT.

and the regulations in force; the meaning of the "absolute block" being that there can only be one train in a given section at the same time, while, under the "permissive" system, there may be more than one train in the section. Prior to the year 1879 it had not been found practicable to work with the block telegraph through busy station yards, and the passage of the train was, in such cases, regulated by a special code of electric bell signals, but this plan was very unsatisfactory, and the difficulty was at length met by the introduction of the "Tell-tale" instrument. This is really a form of block telegraph, worked under "permissive regulations"; but there is a special apparatus, by means of which a reminder is given to the signalman at a station of the number of trains there are in the section in the rear. (See Fig. 12.)

A block instrument of any kind consists of an indicating dial and a commutator or handle. The indicator is attached to an axle, on which a magnet is centred, being suspended either within, or in close proximity to, a coil of silk-covered wire, and deflected to the right or left according to whether a "negative" or "positive" current flows through the coil. The commutator is so arranged as to alter the direction of the current at will. The bells are generally of the single-stroke type, and are used for calling attention, and for giving the complete code of signals descriptive of the nature of trains, as agreed to by all the railway companies.

The normal state of the indicator of the three-wire block instrument is vertical ("Line closed") when no current is flowing; the deflection when a negative current is flowing is to the right, meaning "Line clear," and with a positive current to the left, indicating "Train on line." (A set of the three-wire apparatus is shown in Fig. 13.)

Briefly the *modus operandi* is as follows:—Attention is first called on the bell, and then station A will give to station B what is called the "Be ready" signal, consisting of a certain number of strokes of the bell, varying so as to indicate the nature of the train. The man at station

B, if the previous train has passed his cabin and he knows the section between A and B is clear, repeats this signal. The train is then despatched from A, the signalman at A gives the signal "Train on line," the signalman at B acknowledges this by moving his own indicator and the one at A to "Train on line," and at once gives the "Be ready" signal to C, and so on throughout. As soon as the train has passed B the man at B moves his own indicator and the one at A over to "Line clear," and

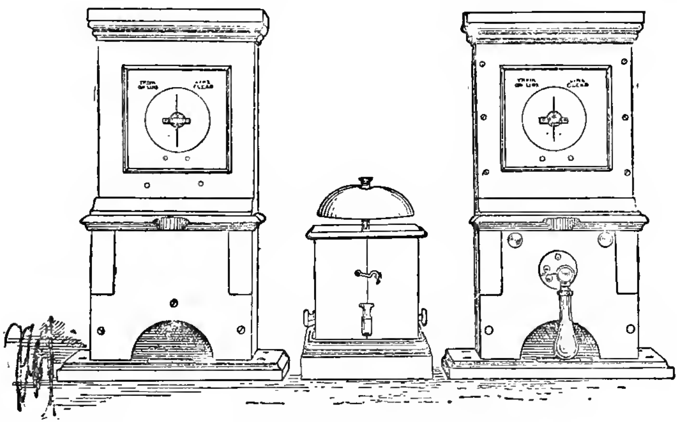


FIG. 13.

SET OF THREE-WIRE BLOCK TELEGRAPH INSTRUMENTS WITH BELL.

upon this being acknowledged by A the indicator is left vertical, signifying "Line closed," and thus the operation has been completed so far as that particular train and that particular section are concerned. Of course it will be apparent that if this system is properly carried out, it is an absolute impossibility for two trains to be between A and B at the same time.

A new form of instrument devised by Mr. G. E.

Fletcher, one of the Company's officials, has been recently introduced on the London and North-Western Railway, by means of which the whole of the apparatus shown in Fig. 13, viz., the indicating dials for both up and

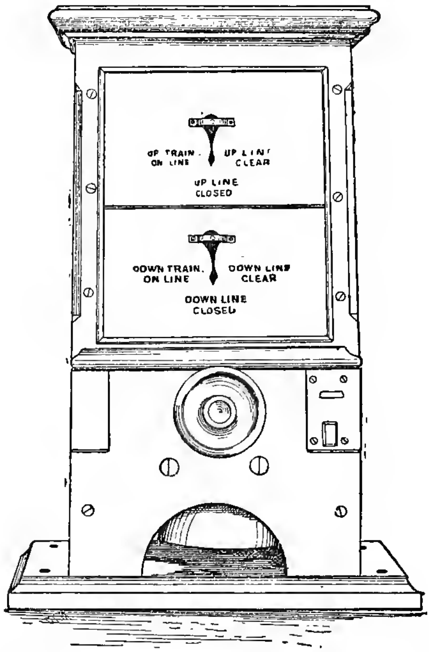


FIG. 14.
FLETCHER'S COMBINED BLOCK TELEGRAPH APPARATUS AND BELL.

down lines, and the bell, are combined in one instrument. (See Fig. 14.) The novelty lies, not so much in the combination, as in the mode of actuating the indicators, the advantages claimed for the invention being (1) a reduction in cost, and (2) considerable economy in space, which is a great desideratum in the smaller signal cabins.

The one-wire system differs from the three-wire, in so far as the indicator of the instrument is moved over to the different positions by a momentary current, and is

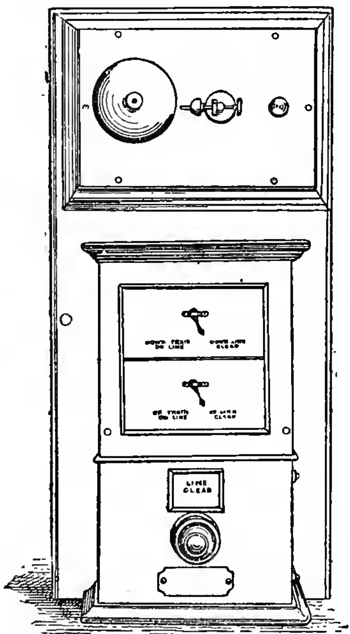


FIG. 15.
ONE-WIRE BLOCK TELEGRAPH INSTRUMENT.

afterwards held there by induced magnetism, the wire being left free for any succeeding signals. The mode of working is about the same, only that there are but two positions, viz., "Line clear," and "Train on line," and no vertical position. (See Fig. 15.)

The "Tell-tale" instruments are somewhat similar in construction to the three-wire, the difference being that the commutator is provided with a revolving disc, lettered "line closed" (indicator vertical), "line clear," and "train on line," and Nos. 2 to 6 on the remaining five sections of the disc. Up to the point of getting one train in the section, the operation is exactly the same as with the ordinary three-wire instruments, but as each additional train is admitted into the section a corresponding disc is brought forward; and also as the trains pass out of the section the same disc is moved back, section by section, until the line is again clear, and the indicator is left at the normal position of "line closed."

It only remains to say that the single-line block telegraph is worked by a similar kind of instrument to the three-wire (absolute block), only there is a commutator at each end, which is blocked over by the station towards which the train is running, keeping the indicators at both signal boxes at "train on line" until the arrival of the train, when they are again released.

Important as the block telegraph is, it is, of course, only an auxiliary to the working of the outdoor semaphore signals, without which it would be impossible to conduct the traffic; and the maintenance of these in a state of perfect efficiency has much to do with the punctual running of the trains. It not infrequently happens that a train will run from London, say, to Liverpool or Manchester without a single "danger" signal being exhibited, or, in other words, that there is a clear road throughout. This efficiency is to a great extent secured by the application of electricity. As is well known, expansion and contraction of the signal wires take place owing to change of temperature, the former preventing, by the elongation of the wire, the pulling of the signal "Off," and the latter, by shortening the wire, preventing the signal from getting properly "On." It is essential that the signalman should know the exact state of his signal, although, by reason of curves or other circumstances, it may be out of his sight, and, in order that he may be so informed, electric signal repeaters have been introduced, the function of which is to send currents from the signal-post, by means of

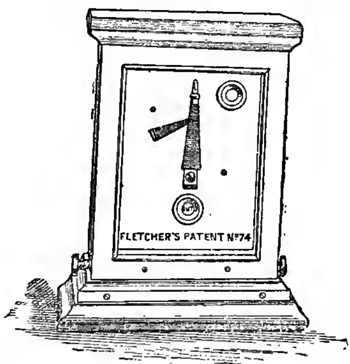


FIG. 16.
ELECTRIC SIGNAL REPEATER AND LIGHT INDICATOR

electric contacts, to a miniature signal-post fitted in the repeating instrument at the signal-box. Up to about three years ago the arm was only shown "On" by current, and "Off" by gravity, but since that time it has been found possible to show "On" and "Off" by current and "Wrong" by gravity; and, in addition to this, the apparatus now in use shows "Light in" and "Light out," one wire, only, being required for the five indications. (See Fig. 16.)

There are many other electrical appliances used in railway working, such as "Train-starting indicators," from platform to signal-box, to inform the signalman that trains are ready to start from certain platforms; "Route indicators" for junction cabins, by means of which signalmen are advised beforehand of the route an approaching train is required to take where the roads diverge; "Vehicles on line" indicators, to show the signalman when a line is fouled by a vehicle being detached from a train and left standing on the line; "Shunting indicators" for station yards, and a variety of other electrical apparatus of a similar character. There is, however, one special appliance which merits a somewhat more detailed description, viz., the "Electric lock" for sidings. This apparatus has been designed to lock and unlock sidings at a distance from the signal-box too far to be worked by rod and lever. There is an instrument at the signal-box, and another at the siding, each containing an electro-magnet capable of actuating an armature which constitutes the lock, fixed in connection with the locking bars of the signal frame. The normal state of the apparatus is "Signals at signal-box unlocked, and siding locked," by the constant flow of a current of electricity through the electro-magnets. If a train, arriving at the signal-box, has to call at the siding, the breakman, or person in chargė, intimates the fact to the signalman, who, by the insertion of an ordinary carriage key into the electrical apparatus, disconnects the wire. This has the effect of locking the signals at the signal-box and unlocking the lever at the siding, and the key can only be inserted when the signals are at "Danger." There is a code cf bell signals drawn up for the guidance of the men, but it will be sufficient to say here that when the train has finished its work at the siding and is ready to go forward, the breakman communicates this by bell signal to the signal-box, and at the same time, by the turning of a button in the front of the instrument at the siding, renews the flow of current, thereby again locking the siding lever and unlocking the signals at the signal-box. The security of the system lies in the fact that, whatever operation takes place at one end, it is only in the hands of the person at the other end to reverse it.

On all the more important main lines the signalmen are enabled to converse one with the other, either by means of the speaking telegraph or of the telephone, which latter is found to be a great acquisition in facilitating the working of the line, more especially through busy station yards.

The mileage of telegraph wires upon the London and North-Western system for purely railway purposes is 11,238 miles, in addition to which there are 6,877 miles of wire appropriated to the use of the Post Office, making up an aggregate of 18,115 miles of wire, while the number of battery cells in work for carrying on the telegraphic business of the Company amounts to 100,323 cells. With such an extent of wires, and so large a number of instruments and batteries in use, it becomes of great importance to provide for a complete and perfect system of maintenance and supervision; but the staff which has to be employed for the purpose is not so extensive as may at first sight appear to be requisite. A line of telegraph has this advantage over a line of railway, that the person charged with the duty of maintaining it in a proper state of repair need not walk from end to end of it in order to detect any fault or weakness. A man can stand at one end of a line of telegraph, hundreds of miles in length, and, by exchanging signals with the other end, may satisfy himself that the entire circuit is in efficient working order. Thus the work of inspection and maintenance of the extensive system of telegraphs in operation on the London and North-Western Railway is carried on by nine inspectors, three sub-inspectors, and forty-eight "linemen." The line is divided for maintenance purposes into nine sections, each of which is in charge of an inspector; and the first daily duty of each inspector is, at a stated time previous to 8.0 a.m., to test all the more important circuits under his charge, and ascertain if they are intact and working efficiently, and the results of this inspection are telegraphed at once to the office of the chief telegraph superintendent, in Manchester, so that that officer has before him, by 9.0 a.m. each day, a condensed report of the exact state of the telegraphic communications over the entire system. By these means it is known where the services of the linemen are required, and some of them are told off to execute necessary repairs, while others undertake the duties of cleaning apparatus, and refreshing batteries. As a general rule, the batteries are cleaned, or refreshed, at fixed intervals varying from ten days to a month, according to the amount of work they have to perform; but it is the duty of any operator who perceives, by the failure or weakness of the indications, that his battery power shows signs of exhaustion at once to intimate the fact to the inspector in charge of the district, and to report any neglect or delay in attending to it to the chief telegraph superintendent.

Electricians are said to be somewhat divided in opinion as to the relative advantages of iron and copper wires for transmitting the electric current, but for overhead wires the London and North-Western Company prefer galvanised iron wires, as having greater tensile strength and superior powers of elongation and contraction, so as to allow for a considerable variation in temperature. The gauges of wire used differ according to circumstances, but the wire chiefly employed has a standard diameter of ·171 inch with a minimum tensile strength of 1,200 lbs., and is subjected to a torsion test of 20 twists in 6 inches. The average life of the wire varies very much according to locality. For instance, in the vicinity of chemical works, as at Widnes and St Helen's, the wire corrodes and requires renewal in about three years, while, in the pure atmosphere of the island of Anglesey, there are wires that have been in use for five-and-thirty years, and which recent tests show to have been very little impaired, whether as regards conductivity or tensile strength; under ordinary conditions, however, the average life of the standard wire is about 10 years.

As regards battery power, the Company use, for speaking telegraph circuits, three wire block telegraph circuits, and electric locks, the Daniell Sulphate Battery; for bell wires the Leclanché Battery; and for signal repeaters, Fuller's bichromate battery.

CHAPTER VII.

Rolling Stock (I.).—Engines and Brake-power.

In order to meet the locomotive requirements of modern times, and to draw long and heavy trains at the high rates of speed now demanded by the public, there has naturally had to be a great development in the engines employed for the purpose, and indeed nothing can be more striking than the contrast between the primitive machines which were regarded as triumphs of engineering skill in the early days of railways, and the magnificent engines which are produced in these modern times. This contrast is very forcibly illustrated by our reproduction in Plate XVII. of a photograph of the old "Rocket," the first engine made by George Stephenson for the Liverpool and Manchester Railway, in 1829, which is still preserved in the South Kensington Museum, and which the reader may compare with the representation in Plate XVIII. of the "Marchioness of Stafford," embodying perhaps the highest form of development of the passenger train engine of the present day. The latter was exhibited by its inventor, Mr. Francis W. Webb, the locomotive superintendent and chief mechanical engineer of the London and North-Western Railway, at the "Inventions" Exhibition at Kensington, in 1885. Let none, however, venture to despise the humble "Rocket," with her wheels with wooden rims, her ungainly appearance, and, as we are now told, her

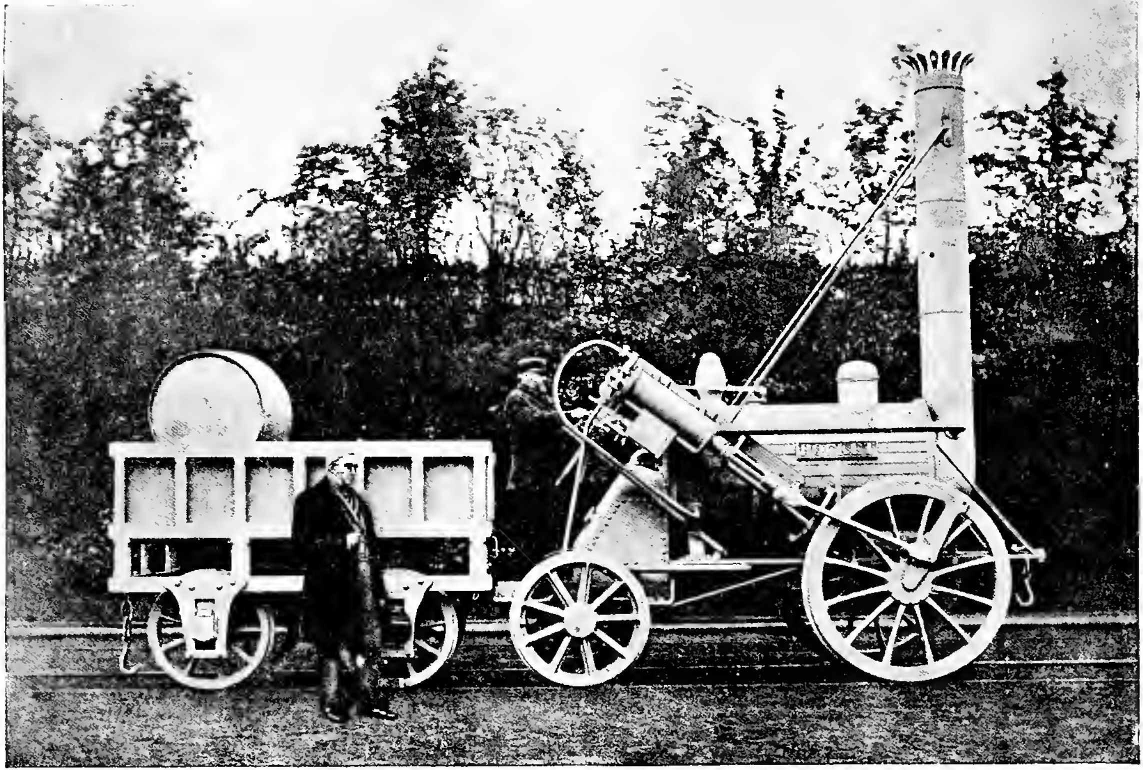


PLATE XVII. THE "ROCKET," THE FIRST ENGINE MADE BY GEO. STEPHENSON FOR THE LIVERPOOL AND MANCHESTER RAILWAY IN 1829.

[Page 98

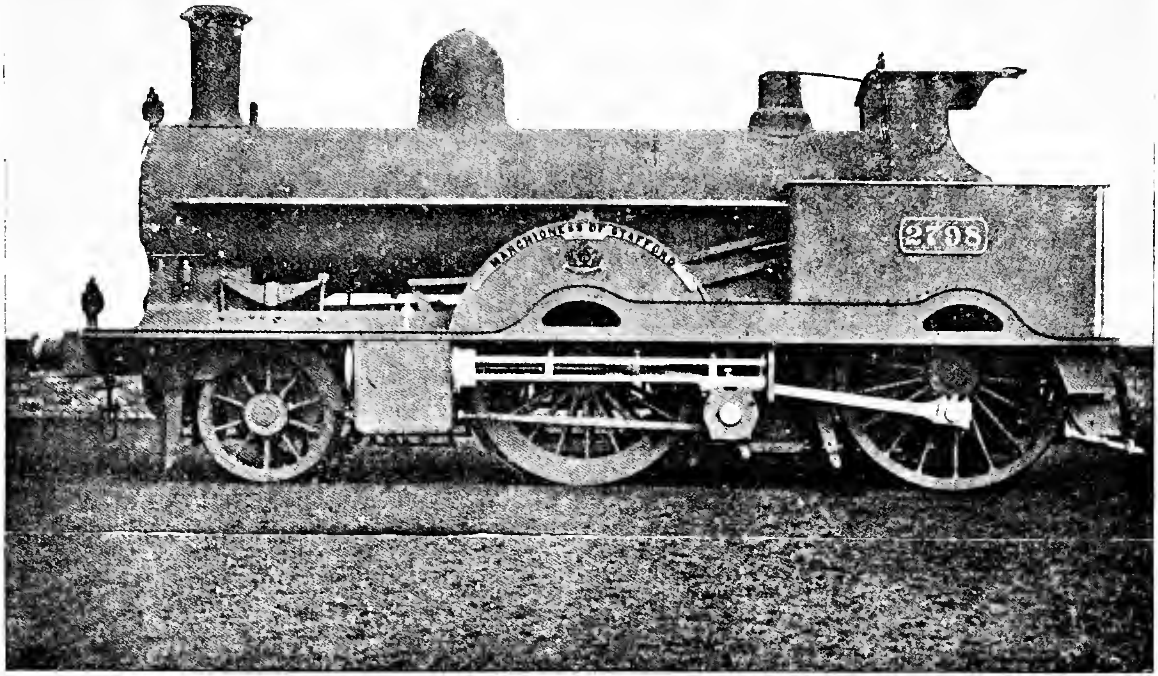


PLATE XVIII. THE "MARCHIONESS OF STAFFORD," 6 FT. COMPOUND EXPRESS PASSENGER ENGINE.

[*Page* 98.

faulty construction, for she was the fruitful mother of a race of giants! It was reserved for the engineers of a later generation to clothe Stephenson's great idea in forms of beauty and of strength, and they are entitled to all credit for the perfection they have attained; but immeasurably greater must be the fame of him whose master-mind first gave the great conception to the world, with all its infinite possibilities of development for the advancement and happiness of mankind. His achievement can only be rivalled, and can hardly be eclipsed, by the genius of the man, perhaps yet unborn, who may endow the human race with a new faculty, by teaching them to navigate the air with the same ease with which they now traverse the ocean and the land.

It is extremely interesting to turn back to the reports of the directors of the Liverpool and Manchester Railway, in 1826, and for some few years after, when the plan for working railways by means of locomotives was still hardly out of the region of experiment, and was not yet freed from a great deal of hostile and sceptical criticism. Thus we find them writing on the 27th March, 1828, when the railway was under construction and the works were well advanced:—

"The nature of the power to be used for the conveyance of goods and passengers becomes now a question of great moment, on whatever principle the carrying department may be conducted. After due consideration, the engineer has been authorised to prepare a locomotive engine which, from the nature of its construction and from the experiments already made, he is of opinion will be effective for the purposes of the Company without proving an annoyance to the public. In the course of the ensuing summer it is intended to make trials on a large scale, so as to ascertain the sufficiency in all respects of this important machine. On this subject, as on every other connected with the execution of the important task committed to his charge, the directors have every confidence in Mr. Stephenson, their principal engineer, whose ability and unwearied activity they are glad of this opportunity to acknowledge."

It is, however, clear, from the perusal of these reports, that even while the works were in progress, and the railway was actually nearing completion, the directors were still somewhat doubtful whether steam engines were the best form of motive power to adopt. Stephenson was at this time continually experimenting, altering, and effecting improvements in his original conception, but the result was not yet conclusive, and in 1829 a prize of £500 was offered for the best engine that could be devised, when Stephenson's "Rocket" was entered for competition, and was successful. The circumstances of this trial, which took place at Rainhill, have been recounted in ample detail by Mr. Francis, in his "History of the English Railway," and by others, and they need not here be recapitulated; but the result was to complete Stephenson's triumph over all his rivals, and to establish the right, which he had so justly earned, to be considered the founder of railways.

The present writer may be excused for taking a special interest in the circumstance just related, inasmuch as he was born at Rainhill in the year 1829, just about the period of the famous trial, his father, who was then engaged under George Stephenson in the construction of the principal viaducts and bridges on the Liverpool and Manchester Railway, being at that time occupied in the building of the Rainhill Skew Bridge. This bridge, which is believed to be the earliest example of an oblique arch constructed in masonry, is still standing, and is a most remarkable work. George Stephenson at this time was so pleased at the result of the trial of the "Rocket," that he presented the writer's father with an English silver lever watch (then a scarce and valuable possession), which is still preserved in the family.

The Liverpool and Manchester directors now commenced to build engines of the "Rocket" type, although with continued improvements; but, as time went on, it was found in practice that the parts were too weak to withstand the heavy wear and tear. The directors were astonished and dismayed at the large expense incurred for renewals and repairs; the engineers were spurred on to tax their inventive powers for still further improvements, and it was thought that a great triumph had been achieved when, in February, 1831, an engine called the "Samson" carried 107 tons of merchandise from Liverpool to Manchester, a distance of about 30 miles, in two hours and a half. It was not, however, until five years later (1836) that the directors felt they could congratulate themselves upon having at length obtained engines upon which they could rely, and, although no model of the engines of this period has been preserved, so far as the writer is aware, there can be no doubt that they were vastly inferior to those in use at the present day.

The London and North-Western Company now employ, for the various purposes of their traffic, engines of eight distinct types, and an Appendix to this chapter gives, in a tabulated form, the details of construction of these different types, including their wheel diameter, cylinders, heating surface, weight, and other particulars.

Our illustration (Plate XIX.) shows an express goods engine with six wheels coupled, cylinders 18 inches by 24 inches, and wheel diameter 5 feet.

Plate XX. shows a special tank engine for goods trains, having six wheels coupled, 4 feet 3 inches diameter, and cylinders 17 inches by 24 inches.

Plate XXI. is an engine used for drawing coal trains, having 6 wheels coupled, 4 feet 3 inches diameter, and cylinders 17 inches by 24 inches.

It was formerly the practice to work the express passenger trains with single engines of the "Lady of the Lake" class (see Appendix), although, later, it was found better to work the heavier trains with four-wheeled coupled engines; but these, having proved to be too small for the increasing loads and the higher rate of speed demanded, are now being superseded by compound engines of a new construction, invented by Mr. Webb, of which the "Marchioness of Stafford" (Plate XVIII.) is an example, and which may be thus described: The engines differ from the compound engines in use on other lines chiefly in the number and disposition of the cylinders, there being two high-pressure cylinders fixed outside the frames, between the leading and middle wheels (the connecting rods working on to crank pins, set at right angles to each other, in the trailing wheels), and one low-pressure cylinder carried between the main frames at the front end of the engine, the connecting rod working on to a single throw crank in the middle pair of wheels. For the benefit of non-professional readers, it may be explained that the underlying principle of a compound engine is that the steam, instead of being allowed to escape after having once done duty, is compelled, by an arrangement of

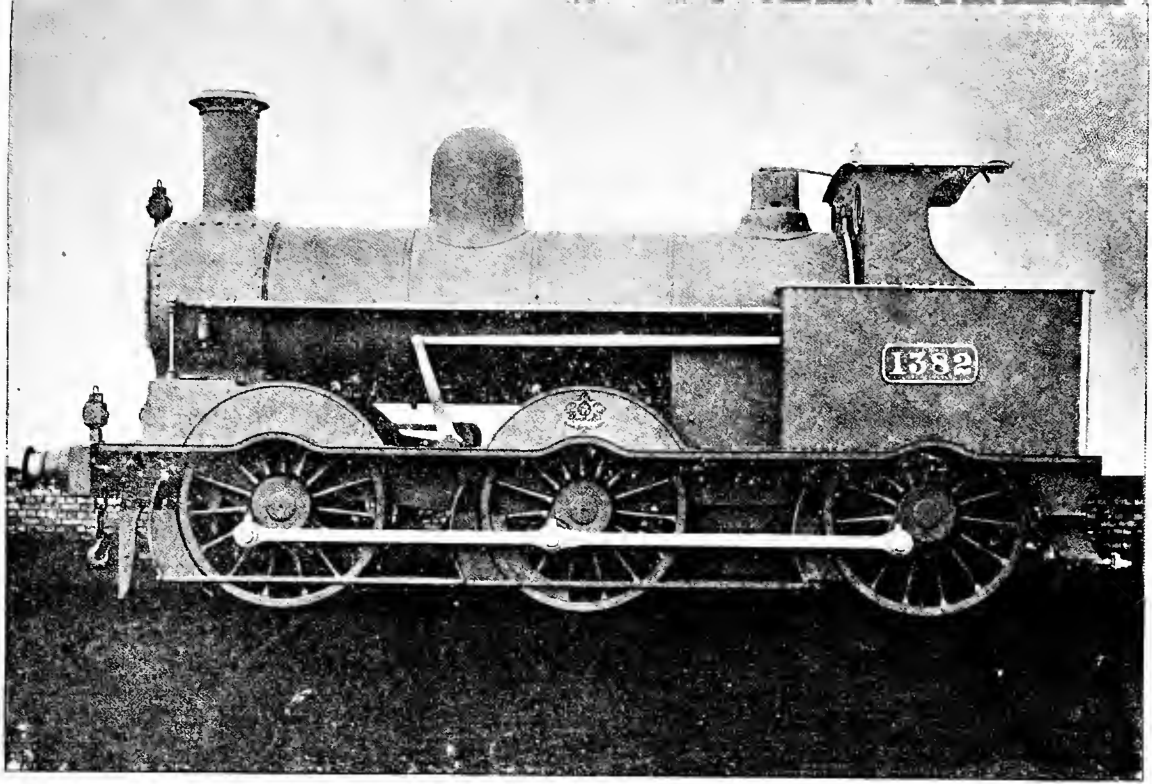


PLATE XIX. EXPRESS GOODS ENGINE, 6 WHEELS COUPLED.

[*Page* 102.

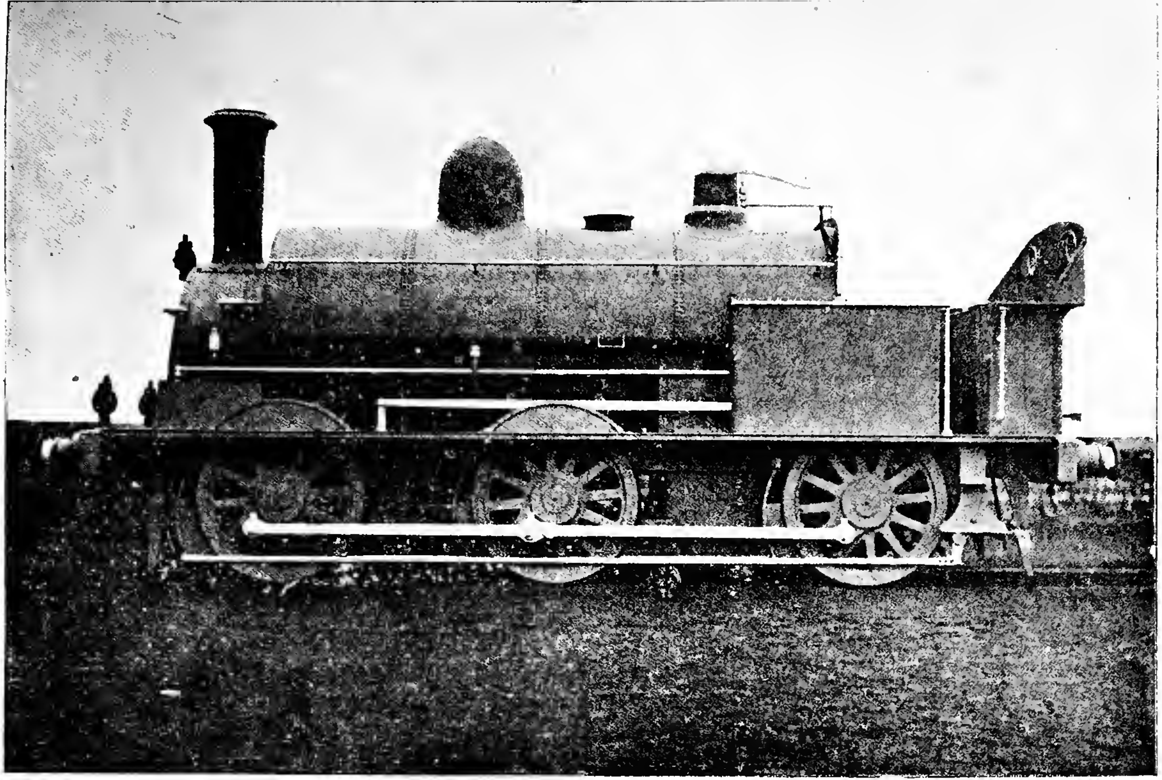


PLATE XX. SPECIAL TANK ENGINE FOR GOODS TRAINS, 6 WHEELS COUPLED.

[*Page* 102.

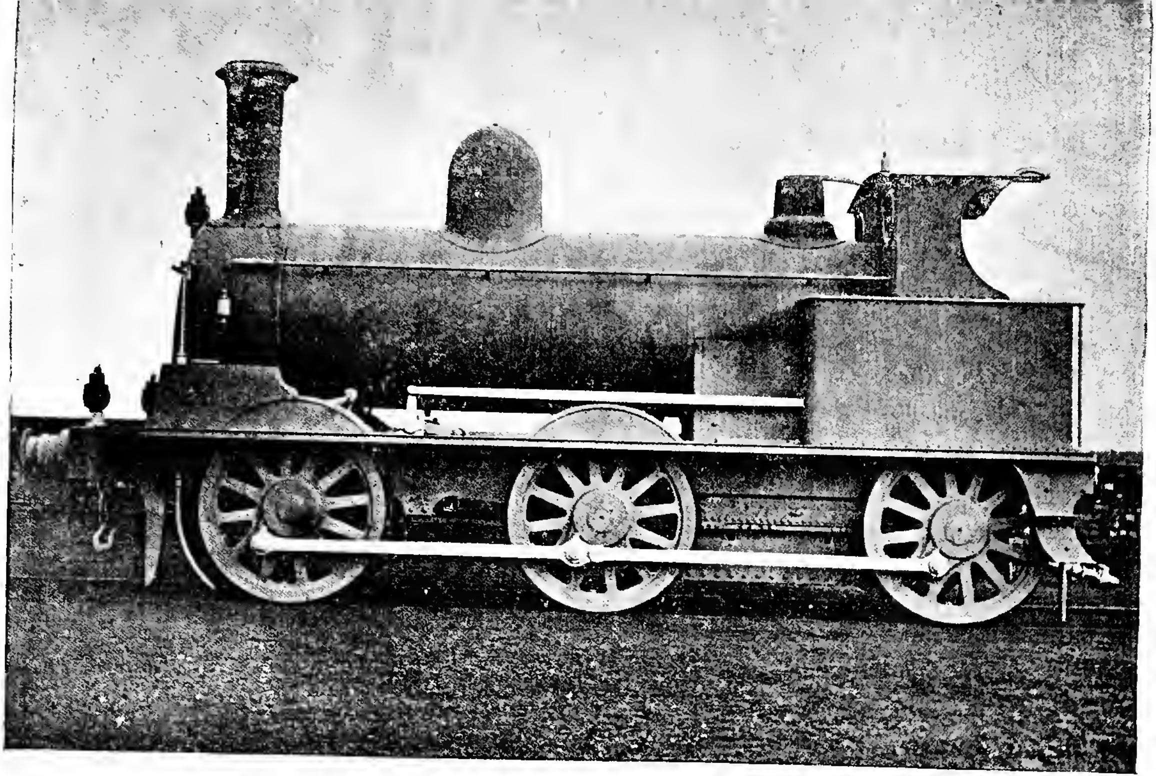


Plate XXI. Coal Engine, 6 Wheels Coupled.

[Page 102

duplicate cylinders, to do duty again, and thus the maximum development of power is obtained, with the minimum expenditure of fuel. The advantages claimed for the improvement are :—

(1.) That the engine, being practically balanced, runs very steadily at a high rate of speed.

(2.) That the power of the engine is distributed over two axles instead of one, as in ordinary non-compound engines, and the strain on the various parts is thus very much reduced.

(3.) The adhesion of two pairs of driving wheels has been obtained, without the use of coupling rods, which become unnecessary.

(4.) The driving wheels may be placed further apart than would be advisable if coupling rods were used, and a larger fire-box can be introduced.

(5.) With independent driving wheels there is less friction in passing round curves, and, if more convenient for the working out of the general design, each pair of wheels may have a different diameter.

The first compound engine was set to work on the London and North-Western Railway in 1881, since which time seventy-three others of the same type have been built, and have run collectively upwards of 11,000,000 of miles. On their first introduction they were met, like all innovations upon recognised methods, by a great deal of hostile criticism, but it is believed that they have lived this down, and are now pretty generally admitted to be a success. An actual trial has shown that, with one of these engines and a train of 321 gross tons in weight, one ton of dead weight can be hauled one mile at a speed of twenty-four miles an hour, with an expenditure of 1·26 oz. of Welsh coal, while to haul the same weight one mile at a speed increased to forty-four miles an hour required 2·06 oz. of fuel—a striking testimony to the great increase in expenses which railway companies have had to incur to keep up the high rates of speed now demanded in railway travelling. The economy of fuel effected by these engines is very considerable, and the fact is not without importance to a Company whose engines consume in the aggregate an average of 3,000 tons of coal per day, or upwards of a million tons in a year.

The compound engines are fitted with "Webb's radial axle-box," which is described as follows:—The axle-box consists of a single casting, with brasses fitted in each end for the journals, and which works between two curved guides formed of flanged plates stretching from frame to frame, thus allowing a lateral motion of 1¼ inch to the axle on either side of the centre line of the engine. Underneath the axle, and within the box, are placed two horizontal helical springs, coiled right-hand and left-hand, and working one within the other, so that when the engine enters a curve the springs are compressed to one side against cross pieces connecting the axle-box guide-plates, and the shock transmitted from the rails through the wheels is minimised, while, as soon as the engine gets on the straight line again, the springs resume their normal position, and the engine is kept central. The axle-box, as originally designed, had two sets of controlled springs placed laterally on each side of the centre line of the engine, but as it was found that there was a tendency, in the case of a broken spring, or of one set being stronger than the other, for the wheels to be forced out of the centre line when running on the straight, the present arrangement was designed to overcome the difficulty. These axle-boxes were introduced in the year 1876, and there are now nearly 700 of them in use on engines, with the result that, in addition to the improved running, a considerable saving has been effected in the wear and tear of the flanges of the wheel tyres. A number of the long 42-feet carriages in use on the London and North-Western Railway have also been fitted with the same species of controlling gear at each end, their rigid base being thus reduced from 32 feet to 16 feet, with the best results as regards easiness of running, and saving of wear and tear; and the steady running of these vehicles in the fast trains running between London and Edinburgh last year was very noticeable. The under-frames of these carriages are constructed of steel, which is found to give them greater strength and elasticity than iron.

In addition to the various types of engines enumerated in the Appendix, Mr. Webb has constructed, for certain special purposes in connection with the railway, some small engines for narrow gauge lines, in which the usual link motion is done away with, and the engine is reversed by a pair of spur wheels, one of these spur wheels being keyed in the driving axle, and the other, equal in diameter, being fixed in a counter shaft, on each end of which is a crank driving the two valve spindles. The spur wheel on the driving axle is a broad one, occupying the space between the two bearings, and the spur on the counter-shaft is a narrow one, and held in position on the shaft by a skew-key, so that, by traversing the narrow wheel across the face of the broad wheel on this key, the relative position of the counter or valve shaft with the driving axle is altered, and so the engine is reversed, thus doing away with all eccentrics and link motion. The construction is simple, and there being so few parts, and those principally having a rolling motion, the engines are not likely to get out of gear, or, if they do, they are easily put right. These engines, of which Plate XXII. contains an illustration, can be driven from either end, and only require one man to work them. Some engines have also been built somewhat similar in construction, but for the ordinary gauge, and are found useful for certain special purposes in connection with shunting yards. It is believed that engines of this type would possess great advantages for the working of military field railways, and that they could easily be protected by armour-plates if necessary.

It may here be mentioned that, in order to facilitate the working of the trains, and to avoid the necessity of their having to stop to take water at places where they are not otherwise required to stop, a number of narrow troughs have been laid down between the rails at convenient distances along the main lines, which, by an automatic arrangement, are kept always filled with water. The tenders attached to the engines have a "pick up" apparatus, provided with a scoop, which can be lowered into the trough while the train is passing over it at full speed, and the tanks are filled with water in a few seconds. Thus, not only is the time saved that would otherwise be spent at the stations in pulling up, obtaining a supply of water, and getting up speed again, but it is possible to use a smaller tender containing a less quantity of water, and consequently there is less dead weight to be handled. These troughs were first introduced by Mr. Ramsbottom in 1857, and, having since been improved and developed, have now been

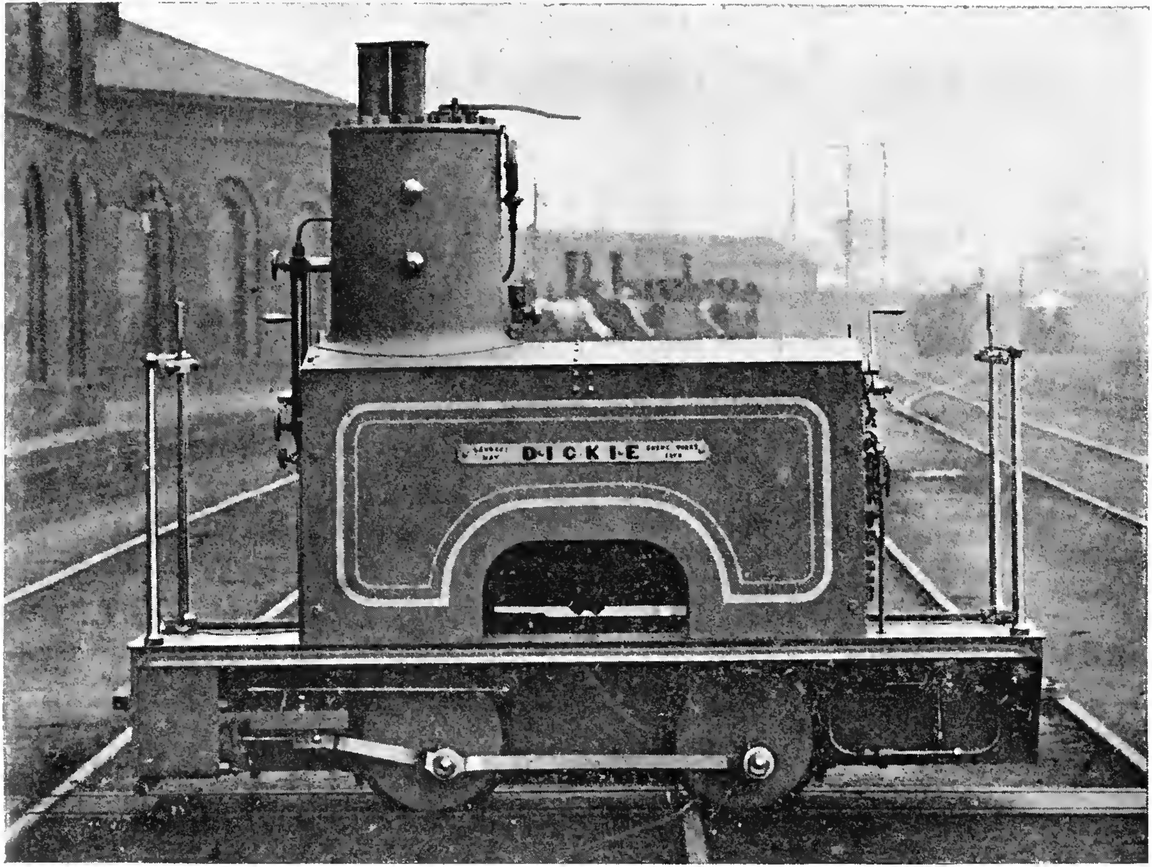


PLATE XXII. TRAMWAY ENGINE, 18 INCH GAUGE. [*Page* 106.

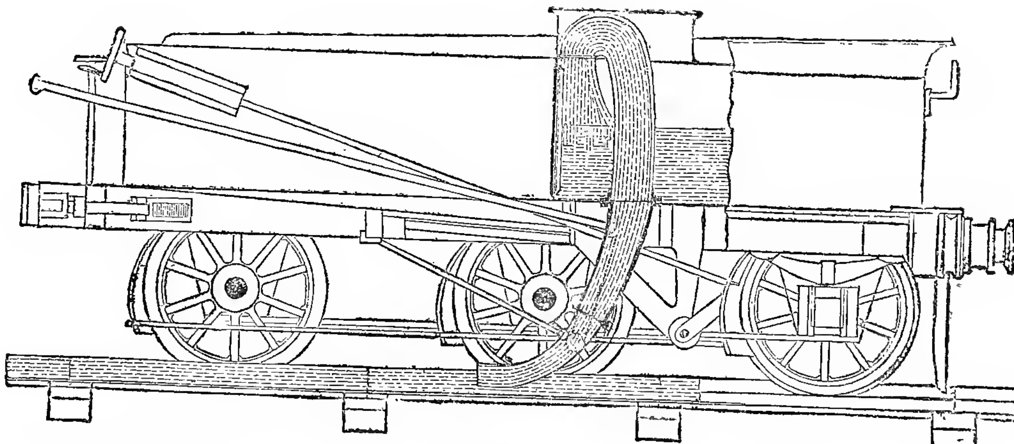


Fig. 23.
Diagram Showing a Tender Picking Up Water from a "Feed-trough" while in Motion.

laid down at eleven different places on the main lines; so that a train may run through, if need be, between London and Carlisle, or Holyhead, without once having occasion to pull up at a water column. Fig. 23 shows, by means of a diagram, the manner in which a tender picks up water from the feed-trough while in motion.

The Crewe works, where the locomotive engines of the London and North-Western Company are manufactured and kept in repair, constitute the largest railway works in the world, and have come, in process of time, to be looked upon as one of the most interesting sights to be seen by almost every Royal or distinguished personage who has visited our shores for many years past, as well as by engineers and railway officials from all parts of the world, who have visited England for the purpose of acquiring information as to the methods and processes of railway working in this country. A brief description of the works, and of what is done there, will not, therefore, be out of place in a work of this character, which professes to give some account of the means and appliances which have resulted in causing a first-class English railway to be regarded as a model for the railways of the civilized world.

The works were originally established in 1843 for the purpose of repairing the engines, carriages, and waggons of the Grand Junction Railway, which was afterwards incorporated in the London and North-Western system, in 1846. As the locomotive requirements gradually increased, the carriage and waggon works were by degrees removed to Wolverton and Earlestown, respectively, and, since the year 1865, Crewe has been exclusively given up to the mechanical and engineering departments, and has become the chief centre of the

London and North-Western Railway Company's works. In 1864 a very important addition was made to the establishment by the erection of works for the manufacture of Bessemer steel, and, as the whole of the space at that time available had been already occupied, these new works were placed a short distance from the junction, adjoining the Chester and Holyhead Railway. This railway had hitherto run through the works, but it was now thought desirable to divert it, and the land lying between the old line and the deviation was utilised for the new workshops, which thus came to be designated the "Deviation Shops," in contradistinction to the "old works." Other additions to the premises have been made from time to time as required, and the total area enclosed now amounts to about one hundred and sixteen acres; the covered shops and mills comprising thirty-six acres. It must be borne in mind, however, that at these works, not only are the engines used upon the railway made and repaired, but a number of other processes of the most varied description are carried on, including the manufacture of steel rails, signal work, the under-frames for carriages, cranes and machinery of all kinds for warehouses, girders for bridge-building, bricks, and joiners' work for houses, stables, and signal cabins, gas, water, and drain pipes, hydraulic machinery, and a multiplicity of other railway appliances far too numerous to catalogue.

The capabilities of the works are such that the Company is enabled to purchase the raw materials and to become the actual manufacturers of every part of the locomotive engines and other machinery constructed at Crewe, with the exception of brass tubes and copper plates.

The total number of engines constructed at these works from their establishment up to the end of April, 1888, was 3,031, of which no less than 146 were constructed in one year, viz., the year ending the 30th November, 1872. In addition to constructive works, however, about 2,000 engines annually undergo repairs, there being usually about 330 in the works for that purpose at one time.

The old works are now entirely devoted to the manufacture and repair of engines, and contain a shop for their erection, three repairing shops, a wheel shop, a fitting and turning shop, a smithy and forge, and a spring shop and copper smithy, as also the offices and general stores. With the exception of the light forgings and smiths' work made in this smithy, the various parts of the engines are brought to the old works in their rough state from other portions of the works; for instance, the frames and other wrought-iron plates come from the plate mill; the crank and straight axles, the tyres, the spring steel, the coupling and connecting rods, and other steel forgings come from the forge at the steel works; and the cylinders, wheels, horn blocks, axle-boxes, and other iron and brass castings come from the foundry. The different portions of the finished work ultimately find their way to the erecting shop, where the actual fabric of the engine is built up, and, as soon as the frame or skeleton is complete, the boiler is added. The engine is then grasped by two overhead travelling cranes, reaching down like giant hands, and is run bodily out of the shop in order that the boilers may be tested. This done, it is conveyed back to the shop, and the boiler is covered in, and all the remaining portions of the internal machinery and the external fittings are added, when the cranes again seize the engine and convey it to the paint shop. Meanwhile the tender has been constructed in another shop. It is now coupled to the engine, the two are painted, and, after receiving a trial, are ready for service. The usual time required in the erecting shop for building an engine is about four weeks, while the shortest time in which any engine has been built in this shop in the ordinary way of business is fourteen days. As an illustration, however, of what could be accomplished at these works in case of emergency, it may be mentioned that some time ago, as an experiment, the erection of an engine was commenced at six a.m. on a Monday, and at one o'clock on the following Wednesday, or within a space of twenty-five-and-a-half working hours from the time the frame plates were selected and laid down, the engine was finished, and in steam, and ready to work a train.

In the fitting shop, which, to the unaccustomed eye, presents a most bewildering appearance, with its endless ramification of pulleys, shafting, revolving wheels, and machinery of every description, all kinds of operations connected with the making of the various parts of an engine may be seen in progress. Here are turning lathes, planing, shaping, slotting, boring, and drilling machines. Here are made the cylinders, the pistons, the valves, connecting rods, injectors, axle-boxes, and a hundred other small fittings and castings, all these being adjusted to standard gauges suitable to the various *classes* of engines, without respect to the individual engine for which they may happen to be used. Thus, to a great extent, the interchangeability of parts is secured, so much so, that four of the standard classes of engines have many of their parts exactly alike, and any of these could be taken from one engine and fitted to another without difficulty, the result being to secure the greatest economy in effecting repairs. To such an extent is this principle carried, that when, as is sometimes the case, one of a pair of cylinders in an engine is damaged, a new cylinder can be straightway procured from the fitting shop and bolted to the remaining one, without any further fitting being required.

The nuts, bolts, pins, and a good many of the small parts are prepared, in an upper room over the fitting shop, by boys, who enter the works as apprentices, and remain at this work for some time before being drafted out as journeymen in the various branches.

The wheel shop, where the wheels and axles of the engines are constructed, is fitted with large and powerful machinery, suitable for the work which has to be carried on, some of the lathes being capable of turning a pair of wheels as much as 8 feet 9 inches in diameter. Interesting features in this shop are the "roughing lathe," in which seven cutting tools are employed at one time in "roughing out" the crank axles, and the "nibbling machine," designed for cutting out the "throws" in the cranks, and which has no less than 160 cutting tools arranged round the circumference of a large disc. An ingenious mechanical contrivance exists in this shop for lifting the wheels and axles into the lathes and other machines. It consists of a series of light jib cranes travelling on a single rail laid on the floor of the shop, parallel with the lathes, and worked by a cotton cord $\frac{5}{8}$ of an inch in diameter, running at the rate of a mile a minute, by which motion is transmitted to the various parts of the cranes. These latter travel along the shop, wherever they are required, at the rate of 80 feet per minute, and lift their loads at the rate of 9 feet per minute. Special light machinery of a similar type has been provided also in the erecting shop, and in the various repairing shops, and is found almost invaluable in facilitating the operations to be carried on.

One portion of the works which seldom fails to interest visitors is the steel works, which, at the time of their opening in 1864, consisted of a converting house with two converters, a cogging shop, and a small forge, but have since been greatly enlarged, the steel-making plant being now capable of producing 50,000 tons of steel per annum, besides which there have been added a large forge, iron, brass and steel foundries, rail-rolling mills, a boiler shop, and several repairing and other shops. To those who are not acquainted with the Bessemer process of converting iron into steel, a brief description of the operation may be interesting

The converting plant consists of four retorts or vessels, each holding 5 tons, and arranged in two groups, with the cupolas behind them. The pig-iron is first melted in a cupola, to which the air is supplied by a Root's blower, after which the liquid metal is run into a huge ladle moving on a line of rails, and is conveyed to the converting vessel. This latter is lined with ganister, and in the bottom of it are a number of small holes, through which air is injected upwards through the molten mass, the oxygen of the air combining with and eliminating the carbon of the iron, and keeping up a fierce combustion until the whole of the impurities are ejected. The blowing is continued for some fifteen or twenty minutes, until the metal is thoroughly decarbonized, when the process ceases, and a quantity, varying according to the quality of steel required, of "spiegeleisen," an iron highly charged with carbon and manganese, previously melted in a furnace, is run into the converting vessel, and combines chemically with the decarbonized iron. The vessel is now turned down and the liquid steel is poured out into a ladle carried at the end of a crane, the crane swings round, and the steel runs out through a small orifice in the bottom of the ladle into cast-iron moulds, and is thus formed into ingots ready to be used for making rails, or for any other purpose required. The air is supplied to the converting vessels by a fine pair of horizontal blowing engines of 450 horse-power, made by Hick, Hargreaves & Co., of Bolton. The steam cylinders are 36 inches in diameter and have a stroke of 5 feet, and the air cylinders are 48 inches in diameter with the same stroke. There are also three reheating furnaces, in which the steel ingots, as they come from the converter, can be reheated, and taken direct to the rolling mill.

The rail-making plant has an annual capacity of 45,000 tons, the rolling mill being driven by a Corliss condensing engine, developing, in ordinary working, about 700 h.p. The rails, while hot, are sawn off to the required length by a circular saw, and, after cooling, are drilled and straightened ready for use.

The powerful forge machinery consists of a duplex steam hammer of 30 tons, and one of 10 tons, together with eight vertical steam hammers weighing from 15 cwt. to 8 tons, tyre rolling, plate rolling, and merchant mills, saws, and shearing machines. The 30-ton hammer was designed by Mr. Ramsbottom, the late chief mechanical engineer of the Company, and consists of two huge blocks, each weighing 30 tons, moving upon rails, with eight small wheels. The blocks are actuated by steam cylinders placed behind them, and on steam being admitted to these, the blocks are propelled with enormous force against the mass to be forged, which is held between them.

An interesting machine to watch in operation, is the large circular saw, 7 feet in diameter, which is used for sawing off the crop ends of forgings, and which is driven by an engine at a great velocity, running at no less speed than 13,000 feet per minute. This will cut its way through an iron axle 9 inches in diameter in 30 seconds.

The tyre mill, plate mill, and merchant mills require no detailed description, as, although the machinery employed is powerful and admirable of its kind, it is analogous to what may be seen at work in other rolling mills, and possesses no features of special interest.

In the steel works there are thirty-seven furnaces for heating the metal, all of which are Siemens' Regenerative Gas Furnaces. There are also seven for making steel by the Siemens'-Martin process, viz., three 20-ton, two 10-ton, and two 5-ton furnaces. The gas for the furnaces is generated in a series of forty-nine gas producers, the gas being conveyed to the furnaces in underground pipes.

Steam is supplied to the various engines and steam hammers by two ranges of stationary boilers, each range consisting of eight boilers of the Lancashire type, 7 feet in diameter, and 30 feet long, with double flues, and constructed entirely of steel plates.

The engine repairing shops occupy an extensive range of buildings, 993 feet long, and 106 feet wide, and are fitted with wheel lathes for turning the tyres of the engine wheels as they become worn, and with all kinds of machinery for effecting the necessary repairs to the various parts of an engine. They are also furnished with boiling pans for removing the oil and grease from the parts when they are taken to pieces for repairs, so that they are turned out well cleaned at very little cost, the grease removed being collected and converted into soap.

It may here be mentioned that up till about the year 1873, the attempts which had been from time to time made to introduce steel into the manufacture of boilers, had resulted in failure, but at the International Exhibition in Vienna, in 1873, a locomotive boiler and fire-box were sent from the boiler shop at Crewe, which were fine specimens of boiler work, and were constructed entirely of steel, and since that time no less than 2,863 locomotive, and 218 stationary boilers, have been made of that material without a single case of failure having occurred other than those due to ordinary wear and tear. The greatest care is taken to ensure the selection of reliable plates for the boilers, a piece being cut from each plate and subjected to the most severe tests of all kinds, and a register being kept of the result of the tests, and of the position occupied by every plate in each boiler.

Extensive brick-making plant exists at Crewe, consisting of two brick-making machines, and a large circular kiln, and drying sheds, the turn-out being some five or six millions of bricks in a year.

The "Deviation Works" previously referred to, consist of a range of shops built alongside the deviation of the Chester and Holyhead Railway, and comprise a chain and plate testing shop, a millwright's shop, devoted to the manufacture and repair of all the shafting and machinery in the works, shops for the making of cranes, warehouse machinery, and stationary engines, joiners' and pattern makers' shops, saw mills, &c.

The check upon stores of all kinds used in the works is very strict, and necessarily so; the stores are kept at the old works, and not the smallest article can be obtained from them without a written order signed by one of the foremen, none but the storekeepers being permitted to enter the stores.

A notable feature in the life of the Crewe works is the narrow-gauge railway, of which nearly five miles have been laid down, traversing every part of the works. The gauge of this railway is eighteen inches, and it is worked by small locomotive engines of the type shewn by Plate XXII., which draw trains of strong, low-wheeled trollies, conveying materials and finished work from one part of the premises to another. It also affords a ready means of locomotion for the workmen and officials from point to point, and visitors to the works seldom fail to make acquaintance with it.

Dining, or "mess" rooms, are provided at Crewe for the convenience of the artisans who live at a distance from the works, and here they can leave their food in the morning, and have it prepared and placed ready for them when dinner-time arrives.

The number of persons of all classes employed in these works is about 6,500, but in addition there are some 600 engine-drivers, firemen, cleaners, and others at the steam sheds at Crewe station, making a total of upwards of 7,000 persons employed in connection with the locomotive department at Crewe. Although the steam sheds referred to form no part of the Crewe works properly so-called, they yet contribute in no slight degree to the establishment of Crewe as the most important locomotive centre of the London and North-Western Railway. About 140 engines are kept in steam at this station daily, for the stabling of which suitable sheds have been provided, covering an area of nearly 2½ acres, and including a washing shed and soap factory. Here the waste and sponge cloths used for cleaning engines all over the London and North-Western system, are washed and dried, and afterwards returned to the stations from which they have been received; the oil and grease collected from them in the process of cleansing being converted into soap, to be used in the various steam sheds.

The Company manufacture and supply gas, not only to their own works, but to the whole town of Crewe, and they also supply water to the works and to the town, the supply being derived from the red sandstone at Whitmore, about twelve miles distant, on the Crewe and Stafford Railway. The water is pumped from a large well into reservoirs, and descends to Crewe by gravitation.

Crewe, which previous to the establishment of the locomotive works was inhabited only by a few farmers and cottagers, has now developed into a flourishing town of thirty thousand inhabitants, composed almost entirely of the Company's workmen and their families, and the tradesmen who supply their wants. In 1877 the town applied for and obtained a charter of incorporation, and Mr. F. W. Webb, the chief superintendent of the works, was elected Mayor for the Jubilee year (1887), being re-elected for the year 1888. In commemoration of Her Majesty's Jubilee, and of the fiftieth anniversary of the opening of the railway through Crewe, the Company presented the town with a public park, about forty acres in extent, which was dedicated by Sir Richard Moon, Bart., chairman of the Company, on the 4th July, 1887, and was formally opened to the public by H.R.H. the Duke of Cambridge, on the 9th June, 1888.

The Company have built, and are the owners of, nearly 800 houses occupied by their workpeople, in addition to which a considerable number have been built by the workmen themselves. The town being almost entirely dependent upon the works, and constituting, in fact, a veritable railway colony, the directors have aided by their countenance, and by material support, every public movement deserving of their liberality. They have erected and endowed a church belonging to the Establishment, and have subscribed to the expenses of building several places of worship of other denominations; have established large schools for the education of the children of the men employed in the works, and erected public baths. They have also provided a Mechanics' Institute, which contains a library of more than 8,000 volumes, a comfortable reading-room, well supplied with newspapers, periodicals, and magazines; class-rooms, a smoking-room, a gymnasium, and a lecture hall seating 800 persons. During the winter months evening classes are held for the instruction, both in elementary and advanced subjects, of the young people employed in the works during the day, and these are largely attended, the fact that since 1871 no less than twenty-four of the students have been successful in gaining Whitworth scholarships, being a sufficient testimony to the character of the results accomplished at this institution. Habits of prudence and economy amongst the workmen are encouraged by the establishment of a savings bank, the Company paying interest at three per cent. on all sums deposited.

The question of Brake-power is one which has an intimate relation to the locomotive department, since it is the great development in the speed and power of the engines employed, which has led to the imperative necessity of devising equally powerful means for bringing the trains quickly to a stand in case of need. The trains of the London and North-Western Company were formerly fitted with a chain brake invented by Mr. Clark, and improved by Mr. Webb, but in matters of this kind continued progress is demanded, and the Company have now adopted a system of continuous brake known as the "Automatic Vacuum," with which the greater portion of their stock has already been fitted. This brake is applied to all the vehicles of a train, except the engine and tender, which are fitted with a separate steam brake. Each carriage carries its own length of train-pipe, flexible hose, and universal couplings; also a reservoir and brake cylinder or "sack," the latter being supplied with a flexible diaphragm and connected through the piston rod with the brake-rigging. The piston rod works through a flexible stuffing-box attached to the bottom of the sack, and which adapts itself to every movement of the rod, but prevents the air from leaking into the sack when it is not required to do so. Attached to the train-pipe, and in connection with the reservoir and the top and bottom of the sack, is an automatic cock, with a valve inside the plug through which the air passes to and from the train-pipe, so that when the air is being exhausted it is drawn from the reservoir, and the top and bottom of the sack, but when air is admitted to the train-pipe, the valve in the cock closes the connection to the top of the sack and reservoir, but leaves the bottom of the sack open to the train-pipe. While the train is running a continual vacuum is maintained in the train-pipes, reservoirs, and sacks, by means of a small ejector on the engine, and in this condition the brakes are "off," but when it is desired to apply them, air is admitted into the train-pipe by the driver or guard; the valve in the automatic cock moves as previously described, and the pressure of the atmosphere, acting on the under side of the diaphragm, lifts the piston rod and applies the brakes. The same result ensues if the train becomes separated or a coupling breaks, air being thus admitted to the train-pipe, and the brakes being applied automatically throughout the train.

When the brakes have been applied, and it is desired to take them off again, all that is necessary is to renew the vacuum by means of the ejector. The driver's brake valve on the engine is so arranged that both the steam and vacuum brakes can be applied simultaneously by one movement of a lever, but the train-pipe may be used without the steam brake if desired, by means of a separate valve provided for the purpose, both on the engine and in the guard's van. By means of the automatic cock previously referred to, the brake on each vehicle may be released while shunting is going on, and may also be shut off if the brake gear is out of order, leaving the train-pipe intact throughout the train.

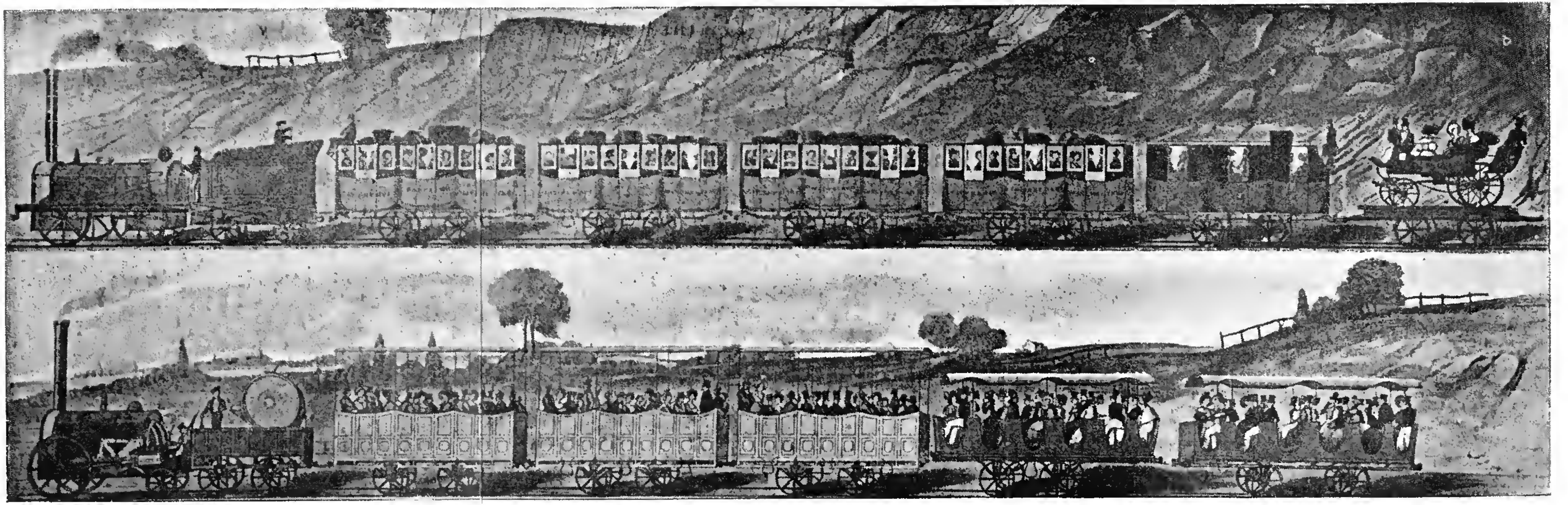


PLATE XXIV. TRAINS UPON THE LIVERPOOL AND MANCHESTER RAILWAY ABOUT THE YEAR 1830.

[To face page 123.

APPENDIX.—DESCRIPTION OF TYPES OF ENGINES IN USE ON THE LONDON AND NORTH-WESTERN RAILWAY.

PARTICULARS.	1 "Lady of the Lake" Class.	2 5ft. 6in. Four Wheels Coupled Class.	3 6 ft. 6 in. Four Wheels Coupled.	4 Six Wheels Coupled (Coal Trains)	5 5 ft. Six Wheels Coupled Special D X Class.	6 5 ft. Six Wheels Coupled 18 in. Goods Class.	7 6 ft. Compound Passenger Engine.	8 6 ft. 6 in. Compound Passenger Engine.
Cylinders—								
Diameter ...	16 in.	17 in.	17 in.	17 in.	17 in.	18 in.	2 High Pressure Cylinders 13 in. diameter 24 ,, stroke.	2 High Pressure Cylinders 13 in. diameter 24 ,, stroke
Stroke	24 ,,	24 ,,	24 ,,	24 ,,	24 ,,	24 ,,	1 Low Pressure Cylinder 30 in. diameter 24 ,, stroke.	1 Low Pressure Cylinder 26 in. diameter 24 ,, stroke
Diameter of Driving Wheels	7 ft. 6 in.	5 ft. 6 in.	6 ft. 6 in.	4 ft. 3 in.	5 ft.	5 ft.	6 ft. 3 in.	6 ft. 6 in.
Wheel Base ...	15 ,, 5 ,,	15 ,, 8 ,,	15 ,, 8 ,,	15 ,, 6 ,,	15 ft. 6 in.	15 ft. 6 in.	18 ,, 1 ,,	17 ,, 7 ,,
Heating Surface :	sq. ft.	sq. ft.	sq. ft.	sq. ft.	sq. ft.	sq. ft.	sq. ft.	sq. ft.
Tubes	981·0	980·0	980·0	980·0	980·0	980·0	1,242·42	980
Fire Box ...	87·3	94·9	103·0	94·6	94·6	103·5	159·1	103·5
Total ...	1,068·3	1,074·5	1,083·5	1,074·6	1,074·6	1,083·5	1,401·52	1,083·5
Grate Area ...	15·0 ft.	17·1 ft.	17·1 ft.	17·1 ft.	17·1 ft.	17·1 ft.	20·5 ft.	17·1 ft.
Weight—								
In Working Order	tons. cwt. 27 5	tons. cwt. 31 8	tons. cwt. 32 10	tons. cwt. 29 11	tons. cwt. 31 5	tons. cwt. 34 0	tons. cwt. 42 10	tons. cwt. 37 15
On Driving Wheels ...	11 10 1 pair	21 4 2 pairs	22 10 2 pairs	29 11 3 pairs	31 5 3 pairs coupled	34 0 3 pairs coupled	30 0 2 pairs not coupled	27 7 2 pairs not cou pled

CHAPTER VIII.

ROLLING STOCK (II.).—CARRIAGES.

MENTION has already been made in a previous chapter of the rude accommodation with which the earlier railway passengers of half a century ago had to content themselves, as compared with the luxurious conditions of modern travel. As illustrative of this wide difference, our illustration (Plate XXIV.) reproduces an old print showing two of the trains which were actually run upon the Liverpool and Manchester railway at, or soon after, its opening. One of these, which apparently represents the very earliest form of passenger train, is drawn by an engine which is a species of first cousin to the famous "Rocket." All the vehicles, as will be seen, are fully exposed to the weather, except for a slight awning overhead, and only a portion of the passengers are indulged with seats, the vehicles, being, in fact, not unlike an open goods waggon of the present day. The upper portion of the picture shows a train containing somewhat superior accommodation, for all the carriages are covered in, although we may be sure that the internal fittings of these ungainly vehicles were very different to the elegantly-furnished saloons of 1888. It will be observed, too, that the luggage of the passengers is piled on the roofs of the carriages, which elevated situation is also occupied by the guards, and that all the carriages have names, "The Traveller," "The Times," etc., like their predecessors, the stage coaches, which they have but recently superseded. Finally, a party of travellers are seen riding in their own family carriage, mounted upon a low truck without removing the wheels, and only dispensing with the horses. Modern advertisements of the running of excursion trains upon railways, frequently to this day announce the fares as "First class—Covered carriages"—and it is well understood that the term "Covered carriages," thus employed, is synonymous with "third class"; but not every one is aware that this expression is really a lingering survival of the period when railway companies, in announcing an excursion, held out the inducement of what was then the unwonted luxury of covered vehicles for the lower classes of passengers.

A striking contrast to the primitive conveyances of fifty years ago is the passenger carriage shown by Plate XXV., which is a specimen of the latest development of the art of carriage-building in these modern times. Forty-two feet in length, with accommodation for three classes of passengers, and a compartment for their luggage, provided with a lavatory for the first-class passengers, mounted upon the easiest of springs, well lighted by gas, and warmed during the winter, adorned with ornamental woods and the handsomest upholsterer's work, and replete with every convenience and comfort throughout, it embodies in fact in a high degree, the latest development of modern civilization as exemplified in railway travelling.

The London and North-Western Company possesses a stock of upwards of 4,500 passenger carriages, of which nearly 300 are forty-two feet in length, and the

PLATE XXV. LONDON AND NORTH WESTERN 42 FEET COMPOSITE PASSENGER CARRIAGE OF 1888.

[*Page* 124.

remainder vary from thirty feet to thirty-four feet in length. Nearly 1,200 of the vehicles are fitted up for lighting by means of compressed gas, and this system of lighting, of which more will be said hereafter, is being extended, the remainder of the carriages being, in the meantime, lighted with rape oil lamps. The whole carriage stock of the Company contains seating accommodation for 164,073 passengers, in the following proportions :—

First class	22,067
Second class . . .	22,506
Third class	119,500
	164,073

these proportions being very carefully considered and adjusted from time to time in building additional carriages, or renewing old ones, so as to preserve the proper ratio of each class to the others. The Midland Company, as is well known, in the year 1875, decided upon abolishing second class compartments in their trains, and retaining only two classes, viz: first and third; but the success of the experiment is believed by many of the companies to be open to serious question, whether upon financial grounds, or as a matter of public convenience. The London and North-Western Company, at any rate, believe that society in this country, for all purposes, naturally divides itself into three classes, and that the wants and tastes of the community are best served by their present practice, in which belief apparently, they are supported by the great body of railway opinion in the country, since no other company has, so far, followed the example of the Midland Company, with the exception of, to a certain extent, the Great Northern Company.

Although, nominally, the passengers who travel upon the London and North-Western Railway are divided into three classes, there are, in a manner of speaking, four classes, for the saloon passengers almost constitute a class in themselves, paying, in some cases, a slightly higher fare than first class, and enjoying superior accommodation. The North-Western have not seen their way to follow the example of their great rivals (the Midland Company) in introducing "Pullman Cars" as used in the United States, in their trains; but they have filled the places of these with saloon carriages of their own construction, which, in their belief, are quite equal, if not superior in some respects, to the Pullman Cars. These are run, as sleeping carriages, in all the night trains between London and Scotland, Holyhead (for Ireland), Liverpool, and Manchester; and, for the payment of a very moderate fee over and above the first class fare, the passenger can secure a berth in one of them, and accomplish his journey without any of the weariness and discomfort, which, until some few years ago, rendered a night journey to the North an experience to be dreaded, and by all means, if possible, to be avoided. The berths are fitted up with beds, pillows, sheets, and rugs, and the traveller may enjoy as sound a night's rest in them as if he were in his own bed at home.

The saloon is supplied with lavatory accommodation, and the passenger, being awakened by the attendant when nearing his journey's end, can make his toilet, enjoy a cup of tea or coffee, provided by the attendant, and alight at his destination refreshed and prepared to commence his business without losing time in repairing the fatigue of the journey. Saloon carriages are also available at all times for parties travelling by day trains, on payment of a certain minimum number of fares, and drawing-room carriages, luxuriously fitted up with couches, easy chairs, and tables, are run by the principal express trains between London and Liverpool, seats in which can be obtained on application in advance by telephone or otherwise, without any charge over and above the first class fare. The Company also provide saloon carriages specially fitted up for the accommodation of invalids and their attendants.

The London and North-Western Company have for many years built their own carriages at their Wolverton works, situated about midway between London and Birmingham. These works cover an area of about fifty acres, and are traversed by what was formerly the main line of the London and Birmingham Railway, but the line has since been deviated, and the old railway has been converted into sidings within the works. In the old days of the London and Birmingham Railway, Wolverton was a kind of "half-way house," and was fixed upon for that reason as the chief locomotive centre; but when the London and Birmingham became amalgamated with other undertakings, some of them reaching to the extreme North and West, and blossomed into the London and North-Western, it was found more convenient to remove the locomotive works to Crewe, and since 1877 the works at Wolverton have been devoted exclusively to the building and repair of carriages and other vehicles used in passenger trains, of parcel carts and vans, omnibuses, station furniture, office fittings, and many other requirements, both for trains and for stations. For all these various purposes, the carriage department employs 2,234 workmen at Wolverton, besides 489 at other workshops which have been established at Euston and Crewe, and 731 men engaged at out stations in executing small repairs, and in cleaning, lamping, and examining the carriages. In the old days, when a journey of moderate length occupied a much longer time than it does now, the Wolverton passenger station was a very important place, having extensive refreshment and dining rooms, but the traveller of to-day is only on the threshold of his journey from London to the North when his train dashes through Wolverton without even deigning to stop there.

With the consent of our readers we will now pay a visit to the Wolverton Works, and endeavour to gain some insight into the method in which the rolling-stock of a great railway is built up and maintained. The smaller companies, of course, do not build their own carriages, but obtain them from one or other of the firms of railway carriage manufacturers in the country.

Entering at the main gateway, facing the old London and Birmingham Railway, and, for the moment, passing by the extensive ranges of shops devoted to various purposes, which meet the eye, we first visit (by way of beginning at the beginning) the timber stores, containing at all times a two years' supply of the raw materials of which the carriages are constructed. Here we find the spoils of the West Indian and American forests in the shape of huge logs of mahogany, baywood, pine, and Quebec oak, the East Indies being represented by teak, largely used in the framing and fittings of the carriages, while English oak and ash are not wanting. Overhead is a high-speed travelling crane which, as we are looking on, seizes one of the great logs in its powerful grasp, and lifts it on to two trucks, standing upon a miniature railway of two feet gauge, which runs throughout the works. The log is rapidly run into the saw mill, and is met on its entrance either by a large circular saw, which speedily converts it into planks, or by a frame saw, which cuts it into boards or panels as required. The planks are next cut into scantling of standard sizes, and are sent to the drying shed to season, or if they already consist of seasoned timber, they are at once marked out, and fashioned into the various parts of a carriage by some of the numerous machines of complex construction and bewildering variety which may be seen on all sides, performing the most complicated operations with the utmost apparent ease and rapidity. Meanwhile, however, we follow our log of unseasoned timber in its new form of planks, or scantling, to the drying shed, where we are shown timber of every description, and of all shapes and sizes, stacked symmetrically, and with the greatest neatness and exactitude, for seasoning, together with piles of mahogany panels, and of veneers of walnut, sycamore, ebony, and various other decorative woods, used for ornamental purposes. These are all labelled and dated, and receive, we are assured, as much anxious care and attention as a connoisseur would bestow upon his bins of choice vintages, for much depends upon the skilful selection and preparation of the materials from which the carriages are built.

The parts and sections, which we have seen cut out of the seasoned timber in the saw mill, are run by means of the small tramway into what is termed the "body shop," where they are put together by the coach-makers, and begin to assume the rough outline of the body of a carriage. This is raised by a crane, and lowered on to the under-frame already prepared for it, and which is constructed of channel steel, with Mansel wheels and radial axles. The vehicle, in its rough state, is next taken forward to another shop, where it undergoes long and tedious processes of rubbing-down, painting and varnishing; and meanwhile, the internal fittings, linings, and other upholsterers' work, which have been prepared in various shops devoted to such purposes, are put in, and the break gear and gas fittings are added. Finally, when the carriage is quite complete, it is placed in a cool airy shed, for the paint and varnish to thoroughly harden, before it is turned out for use in trains.

The making of the wheels for the carriages is a very interesting process, and will repay a visit to the wheel shop. The wheels are made without spokes, the centres being solidly built up by segments of teak compressed by hydraulic power. Passing the formidable double row of wheel lathes, which, with apparently very little attention from the workmen, are cutting long spiral shavings of steel from the tyres very much as one pares an apple with a sharp knife, or boring out tyres, and cutting the grooves for the retaining rings, which, when in position render it impossible for the tyre to leave the wheel, even if it is broken into several pieces, we arrive at the machinery by which the wheels are finally put together. A steel tyre, spun from a solid block of Bessemer steel, without a weld, is swung up by a hydraulic crane on to the press, the teak segments, already cut and shaped with the greatest nicety by an automatic machine in the saw mill, are placed in position within the circumference of the tyre; the press is closed up, and a handle is turned, which sets the hydraulic ram in motion. Soon we hear the solid teak blocks begin to groan as they are forced into the tyre, and with a few loud thumps they are driven home, when the press is opened, and the wood-centre is seen to be as compact as if it were fashioned out of one piece of timber. Nothing remains but to add the retaining ring and boss plates; another hydraulic press forces the wheel and its fellow on to the axle and keys them up; and one more pair of wheels is added to the many thousands that are ceaselessly rushing to and fro upon the iron highway.

Making a tour of the premises, we shall observe that there are special shops and rooms for almost every portion of the work which has to be carried on. Here for instance, is a shop devoted to the fine cabinet work required for the internal fitting and decoration of the carriages, and close at hand is a room where a staff of girls is employed in French polishing. The body shop, paint shop, and drying rooms, we have already seen; but here is a carpenters' shop, where furniture, ticket-cases, barrows, and similar articles are made; a smithy, where brawny workmen are wielding the heavy sledge-hammers, and fashioning all kinds of intricate ironwork; a spring makers' shop; brass and iron foundries, where casting is going on, and the molten metal is spurting from the cupola furnaces; a lamp shop, with its deafening sound of the ceaseless tapping of tinmen's hammers, and rooms where women are busily engaged in cutting out and making up the trimmings and linings of the carriages; while everywhere we cannot fail to be struck by the ingenious mechanical appliances which mimimise the labour, and secure uniformity in the work, although these are too numerous and complicated to be described.

Before leaving the works we must pay a visit to the laundry, where some half-dozen women are engaged in washing the linen and towels used in the saloon carriages, all of which are sent to Wolverton daily to be washed, in exchange for a clean supply, about 4,500 articles being thus dealt with every week. Most of the work is done by steam, supplied by a small vertical boiler, the linen being dried in a hot closet, and very scrupulously aired before being sent away, so that passengers never need have before their eyes the fear of damp sheets, in the sleeping saloons.

It is a somewhat interesting sight to watch the operation of paying the large number of men engaged in these works; and the method employed to facilitate the task, and avoid mistakes or disputes, is not without ingenuity. The whole of the men employed are numbered consecutively from one upwards, and at pay-time they arrange themselves in numerical order in a large yard, so as to form a *queue*, and pass the pay-window in single file. Each man, as he passes the window, hands in his pay check, and receives in return a tin box stamped with his number, and containing his wages. At the end of the passage is a receptacle, into which he throws the empty box, this being considered his receipt for the money; since any question as to the correctness of the amount must be raised before he parts with the box. The money is, of course, counted out and placed in the boxes beforehand, and so simple is the process, and so expert are the clerks employed, that the whole of the men, upwards of 2,000 in number, are paid and the business is at an end in less than half-an-hour.

The physical and moral welfare of the men are not lost sight of, but are promoted in many ways. There is, for instance, a spacious dining-hall, with accommodation for 1,000 men, each seat being provided with a coffee can and cup, and a cooking tin. Adjoining the dining-hall are large kitchens fitted with ovens, boilers, and hot-plates, where the workmen can either procure their meals at a small cost, or can bring their own provisions, and have them cooked free of charge.

Near the works are schools, largely supported by the Company, where the children of the workmen are educated for a very small fee, while near the schools is a Science and Art Institute, a handsome brick building, in which so much good work is being done, that an extension of the premises will very shortly be necessary. The Company have provided also a spacious recreation ground near the station, and the men can boast of a promising amateur athletic club, cricket and football clubs, and a strong and efficient company of the County Volunteers.

Wolverton, to a great extent, resembles Crewe in being a railway colony, the inhabitants of which are all engaged in one occupation, and although a considerable number of young women are employed in the works, there were formerly a great many girls, the daughters of the workmen, who could find no occupation. Seeing this difficulty, Messrs. McCorquodale and Co., the Company's stationery contractors, considerately came to the rescue, and by erecting a large envelope factory in the immediate neighbourhood, have provided suitable employment for tne surplus female population.

Apart from the carriage works at Wolverton, the superintendent of the carriage department has under his orders, at what are termed "Out-stations," a staff of nearly 1,200 men, who are engaged in the repair, examination, greasing, lamping, washing, cleaning, and warming of the carriages throughout the system, and it may be useful to give some account of the manner in which these very necessary operations are carried on.

Examination.—About one hundred carriage examiners are employed, who are stationed singly or in small gangs at the most important stations and junctions from one end of the line to the other. Before any man is appointed to a post of this kind he must have had previous experience in the lifting and repairs of carriages in the shops, and it is his duty to carefully examine the wheels, springs, and other running parts of all carriages standing at, or passing through, his station, tapping every wheel-tyre with his hammer, so that his experienced ear may detect by the sound whether they are in good order and without flaw. Where no special staff of coach repairers is employed, the examiner has also to attend to slight repairs of internal fittings, defective locks, etc. At the more important stations pits are provided between the rails to enable the examiners to get beneath the carriages to inspect the under-gear.

Greasing.—This is attended to by men stationed at the principal stations and junctions under the orders of the examiners, their duty being simply to examine the axle-boxes of every carriage passing through their station, and replenish them with oil or grease when required.

Washing.—Every carriage is washed outside with water once each day, the water being usually obtained from cast-iron tanks let into the ground, with a self-acting ball-valve. The buckets can thus be filled instantaneously, without the loss of time involved in drawing water into them from a tap. At the large stations there are sheds specially provided for carriage washing, having wooden stages the height of the carriage floors, alongside each line of rails, with wrought-iron troughs running the whole length of the stages, which by the ball-valve arrangement are kept constantly full of water. Periodically, of course, the outsides of the carriages require something beyond the simple washing with water, and have to be thoroughly scoured with soap or some cleansing composition. The equipment of each "washer" consists of a bucket, a long-handled brush, with which he can reach from the ballast, if need be, the tops of the carriages, and a small spoke-brush for getting into corners, etc.

Cleaning.—The "cleaners," of whom a large number are employed, attend to the insides of the carriages. They are provided with a bass broom, a hard hand-brush, and a soft one, a wash leather and a linen duster. They are expected to shake each carpet, well brush the linings and cushions, clean the windows, and finally to dust the whole carriage throughout.

Heating of Carriages.—During the cold weather, that is to say generally from the 1st November to the 31st March in each year, every compartment of each class is supplied with at least two foot-warmers. The ordinary foot-warmer is an oblong tin, filled with water through an orifice which is then hermetically sealed, and the warmer is placed in a boiler until the water is heated. A patent foot-warmer has, however, been introduced, and is now in use on all the main lines, in which the water is replaced by acetate of soda. The utilisation of crystalised acetate of soda for this purpose is of comparatively recent introduction, the advantage consisting in the fact that the heat, before it has altogether disappeared, can be restored by merely shaking the receptacle, and that the heat is retained nearly three times as long as in the ordinary hot-water tins, viz., for about 8 hours, thus avoiding the inconvenience and annoyance to passengers of continually changing the foot-warmers on a long night journey. The acetate of soda used for this purpose should possess a slightly alkaline re-action to litmus test paper, and should be commercially free from sulphate-chloride and carbonate of sodium, as well as from acetate of lime. It should not possess any unpleasant odour of tarry matter, and its total impurities should not exceed 2 per cent. The warmers are charged in the following manner :—The acetate of soda is first placed in a large iron tank and reduced by heat to a liquid, of which seven quarts are placed in each warmer. Seven ounces of water are added, and two cast iron balls, each two inches in diameter, and weighing 20 ounces, are placed inside. The aperture at the end, through which the liquid has been introduced, is now covered by a cap, soldered down, with a small hole left in the centre. The warmer is placed in another tank, and the contents again brought to boiling point, when the receptacle is hermetically sealed, and is then ready for use.

The sleeping saloons in the through trains between London and Scotland, Holyhead, Liverpool, and Manchester, are warmed by means of high-pressure hot-water pipes, each saloon being supplied with a small heating apparatus for the purpose.

The Lighting of Carriages.—Until recent years the carriages upon the London and North-Western Railway were all lighted by means of oil-lamps, but this plan is being gradually superseded by the introduction of a system of lighting by compressed oil gas, about 26,000 oil lamps being, however, still in use. At all stations where the lamping of trains is performed, separate rooms are provided, as remote as possible from the station buildings, to lessen the risk of fire. These rooms are furnished with tables having iron frames and slate tops, with benches for cleaning and filling the lamps, wooden stands for cleaning the lamp cases, and racks affixed to the walls, in which the lamps are placed when cleaned, trimmed, and ready for use. The rooms are also fitted with iron tanks for the oil, waste bins, and sawdust bins. On the arrival of a train the lamps are removed from the carriages, placed on a truck specially constructed for the purpose, and taken to the lamp-room, where the cases are cleaned, the burners filled, and the wicks trimmed, when the lamps are replaced in the train, or placed in the racks, as the case may be.

The system of lighting by oil gas, previously referred to, is the patent of Mr. Pope, the gas being manufactured from shale oil. At the stations where this gas is made and supplied, the oil is brought to the works in barrels, and emptied into a large covered iron tank, let into the ground outside the gas-house, being afterwards pumped thence into a smaller tank, placed at a high level inside the gas-house. From this it is allowed to gravitate to red-hot retorts, through a small jet pipe, and is vapourised, afterwards passing through a hydraulic main to the condensers, thence to a coke scrubber, and, finally, through a registering meter to the gas-holder. The gas is stored in reservoirs about 18 feet long, and about 4 feet in diameter, built up of

½-in. plates, to stand a working pressure of 150 lbs. to the square inch. The reservoirs are provided with gun-metal inlets and outlets, and also with a low-level outlet, to admit of drawing off the hydro-carbon which is thrown down owing to the compression of the gas. A combined engine and pump is employed to pump the gas from the reservoir to the receiver, whence it is conveyed by pipes to the cylinders attached to each carriage, at a pressure of 150 lbs. to the square inch, each cylinder, as well as the main, being supplied with a pressure gauge, so as to show at a glance when they are full.

The gas is conveyed from the works where it is made, to the station or shed where the carriages are charged, through an underground main of iron pipe, having an outside diameter of 1¼ in., and an inside diameter of ¾ in., connecting hydrants are then attached to the main, to which gas-hose is attached at distances of about 120 ft. for filling the cylinders in the carriages. The hose is of india-rubber and canvas knit together, and is capable of withstanding a pressure of 150 lbs. to the square inch; it has attaching unions and stopcocks at each end, so that it can be taken off the main without waste of gas, the main and the carriage cylinders having stop valves, so that all can be closed before detaching the hose. The gas in the main can also be drawn off into the gas-holder when it is desired, for any reason, to empty the carriage cylinders. Each carriage has one or two cylinders, which are filled to a pressure of 110 lbs. to the square inch, and are made of lined steel, with the seams welded, and two of these, 16 feet in length, with a diameter of 13 in., will carry a sufficient supply of gas to keep twenty lights burning on a journey from London to Aberdeen and back. Gas cannot be consumed under this high pressure, but has to be passed through a regulator, so as to reduce it to something like the pressure of coal gas as used for household purposes, and this is effected by a very simple contrivance. The gas passes from the high pressure cylinder through a small needle hole, with a pin valve and lever attached to a diaphragm, in a round box. As soon as 9·5 water gas gauge pressure has entered this box, the diaphragm rises and closes the valve, which does not re-open until the lights are turned on, when it admits gas at the same rate at which it is consumed at the burners. Each jet can be regulated to a given size, so that it cannot blaze and cause waste, and all the lights in a carriage can be turned off or half-off, by a key at the end of the carriage. Finally, each carriage has a pressure gauge to indicate the pressure of gas in the cylinders, and to shew when the supply is exhausted.

It must not be supposed that the London and North-Western Company, in their endeavours to secure an improved system of lighting their passenger carriages, have overlooked the question of electric lighting, or that they have been oblivious of the experiments which have been made in this direction upon various railways, but chiefly upon the Southern lines. They are, on the contrary, perfectly alive to the fact that in all probability the electric light is the light of the future for railway carriages, as for most other purposes; and they have not been behindhand in making experiments with it on their own account. For some time past one of their trains running between Liverpool and Manchester has been lighted by electricity, and not without success; and although the directors, regarding the question as only in a transitional or experimental stage, have not yet seen their way to adopt the system to any large extent, a brief account of what has been done may perhaps be of interest.

It is tolerably well known that there are at least three methods in which a current of electricity may be obtained for lighting the carriages of a train. A primary battery may be used, or secondary batteries as on the Brighton line, or the dynamo may be used direct. Each system has its own supporters, but the greatest consensus of opinion, at any rate amongst railway engineers, appears to be in favour of either the secondary batteries, or the direct action of the dynamo, while possibly the ultimate solution will be found in a combination of the two; that is to say, the train will carry both a dynamo and accumulators; but whether the dynamo is to be carried on the engine or driven from the engine direct, or is to be driven by a separate engine, or by the axle of the guard's van, are points not yet determined with any degree of authority. The train already referred to on the Liverpool and Manchester Railway, carries a Brotherwood's engine and a Siemen's compound shunt dynamo fixed on the tender of the locomotive, with an ammeter and switch on the engine, so that the driver may regulate the current, and there are two lamps in each compartment of the train with an automatic switch arrangement, so that in the event of one lamp failing, the second would be automatically brought into use. The system, which has been devised by the Company's chief telegraph superintendent, does not admit of the engine leaving the train without disconnecting the current, but this difficulty might be overcome by the use of secondary batteries or accumulators. The capital outlay required for the installation of this one train, including the Brotherwood engine and dynamo machine, was £286, and the working expenses for a year have amounted to £84 2s. 1d., which works out to about ·628 of a penny per lamp per hour, but this has since been somewhat reduced, and moreover, a portion of the working expenses would be no greater if there were three or four trains to attend to, working between the same points.

CHAPTER IX.

ROLLING STOCK (III.)—GOODS WAGGONS.

PRIOR to the year 1881, the railway companies, generally speaking, only provided waggons for the conveyance of ordinary merchandise, and coal and coke, lime, salt, and some other commodities were carried in waggons belonging to the colliery proprietors and other traders, the companies making an allowance off their authorised tolls, for the use of the vehicles, and the owners performing all the services of loading and unloading. To a very considerable extent, this state of things still prevails, but in the year previously mentioned (1881) the Midland Company decided upon the new policy of becoming the owners of nearly the whole of the waggons running upon their railway. They accordingly obtained Parliamentary powers to raise a large sum of money for the purpose of buying up waggons from private owners, and building others for the conveyance of coal, and other traffic, and they now possess nearly 38,000 coal and coke trucks of their own.

The London and North-Western Company have also provided waggons for coal traffic, but not to so large an extent, as at the present time they have only some 6,000 coal waggons (including nearly 3,000 which are used for the conveyance of their own coal for locomotive purposes), and the bulk of the coal traffic upon their railway is still conducted by means of waggons owned by the traders. Of course, where the railway company find the waggons, they make a fair charge for their use, which charge varies from 6d. to 1s. per ton according to distance and other circumstances.

It must be confessed that the Midland Company's new departure was not without some justification in the fact that private owners' waggons are, always have been, and probably always will be, a fruitful source of trouble and anxiety. A railway company, in building its stock, has too much at stake to risk sacrificing efficiency to economy, and the vehicles are constructed with the utmost solidity and perfection of workmanship, without regard to cost; but the same considerations do not apply with equal force to private traders, and the companies are obliged to exercise the most stringent precautions, both in the matter of imposing a certain standard of construction and maintenance, and in keeping up a watchful system of examination, in order to guard against unsuitable waggons being run in their trains. The breaking down of a waggon may endanger the safety of a whole train, and cause the loss of valuable lives and property, and a very complete and elaborate system is adopted, with a view to guarantee that every private waggon shall be properly built and maintained. The system is as follows:—

A "Standard Specification," accompanied by drawings and dimensions, is drawn up, and private owners are required to build their waggons strictly in accordance with it, down to the minutest details, working drawings and descriptions of the waggons being first submitted for the approval of the Company's waggon superintendent before the work is commenced. When the waggons are complete and before they are permitted to run upon the railway, they are examined by the same official, and if he is satisfied that all the requirements of the specification have been faithfully complied with, he affixes to each side of each waggon a register plate, bearing the name of the Company, the registered number, the date of registry, and the maximum load to be carried. The waggon, with the plate so affixed, is free to work over the Company's, or any other, line of railway, the arrangement being a mutual one between all the railway companies in the Kingdom agreed to at the Railway Clearing House.

The registration in no way affects the right of any railway company to inspect a registered waggon, and if found in any way defective, to stop or refuse it, and when a waggon, which has been approved, is repaired, or any of the parts renewed, the work must be carried out in accordance with the standard specification. The owners of the vehicles are required to keep them in a perfect state of repair, and to have them thoroughly greased and properly examined before each journey, any station-master being authorised to detain a waggon which appears to him to be unfit to travel.

Careful precautions are taken to see that every waggon, whether private or belonging to the Company, is in a fit and proper state of repair and efficiency while running in the trains, and the instructions issued to the men who are charged with this duty are of the most minute character. A staff of 220 examiners and greasers is employed, and these men are posted singly or in gangs at every important station and junction throughout the system. They are held responsible for seeing that every vehicle on commencing its journey from their station is in good and safe running condition, that the wheels, axle-boxes, springs, buffers, draw gear, brakes, and all other working parts are in perfect order, that the axle-boxes are well greased, and that any waggon in which a defect is discovered is promptly shunted out of the train, and a red card affixed to it to indicate that it is not to run until the necessary repairs have been attended to.

When a through train is standing at a station or junction, where it is required to stop, it is met by an examiner, whose duty it is to pass along each side of it and examine every wheel, not only by means of the tapping hammer, but by personal inspection. He also examines the axle-boxes, to see that they are well greased, and are not running "hot," and watches the revolving of the wheels, in order to detect a bent axle, stress being laid upon the fact that in the event of a waggon being stopped with a bent axle, no attempt is to be made to straighten it while cold, but the wheels are to be taken out and sent to a repairing shop where the axle can be heated, and thus properly and safely straightened.

The following are the minimum dimensions of axles to be allowed, which a long experience has dictated as representing the limits of safety, and any waggon found running with an axle of less dimensions is stopped and treated as a defective vehicle :—

	Wheel Seat.	Middle.	Journal.
	Ins.	Ins.	Ins.
For 6-ton waggons	$4\frac{1}{4}$	$3\frac{1}{2}$	$2\frac{3}{4}$
„ 7-ton „	$4\frac{1}{2}$	$3\frac{3}{4}$	3
„ 8-ton „	$4\frac{1}{2}$	4	$3\frac{1}{4}$
„ 10-ton „	5	$4\frac{1}{2}$	$3\frac{1}{2}$

No tyres are allowed to run if they are less than 1 in. thick on the tread.

The London and North-Western Company possess in all upwards of 56,000 waggons of various descriptions, including the 6,000 coal waggons previously referred to, and the whole of these have been built, and are kept in repair, at their own waggon works at Earlestown. Of the total number nearly 34,000 are open goods waggons, 15 ft. 6 in. in length, and 7 ft. 8 in. in width, 20,000 of these having low sides only 9 in. in height, while the remaining 14,000 have sides 1 ft. 8 in. in height. There are 4,000 covered goods waggons, 15 ft. 6 in. long, 7 ft. 8 in. wide, and 5 ft. 8 in. in height, at side. The rest are vehicles of some forty different descriptions constructed for special classes of traffic, and having varying dimensions. The frames are all constructed of well-seasoned English oak, and the bodies of oak, teak, or red pine, the carrying capacity of the bulk of the waggons being 7 tons. The wrought iron work in the under frames is of the best Staffordshire iron, with the exception of the couplings, for which iron from the Low Moor furnaces is found to be the most suitable. The axle-boxes, buffer-shoes, and bearing spring shoes are of the best cast iron, and the wheel tyres and axles are of Bessemer steel.

The Earlestown works, although not quite so extensive as the carriage works at Wolverton, yet cover an area of thirty-five acres, and employ at busy times about 1,600 men, who are engaged in constructing and repairing, not only waggons, but the whole of the carts and vans required for cartage purposes throughout the Company's system. The works comprise a waggon-maker's and wheelwright's shop, 463 ft. long and 291 ft.

in width, a saw mill 200 ft. in length, two smithies containing over one hundred fires, a timber shed, turning and spring-making shops, foundries and forges, and numerous other shops devoted to various purposes, all fitted up with the most powerful and efficient machinery for minimising labour and ensuring accuracy of workmanship. The capacity of these works may be judged from the fact that when the full complement of some 1,600 hands is at work, they can turn out about eighteen finished waggons during the working day, or at the rate of one waggon every half-hour!

Most of the institutions which exist at Wolverton for the benefit of the men employed are represented by kindred institutions at Earlestown. Thus, there is a commodious dining-room, capable of seating 400 persons, where the men and boys employed in the works can have their food cooked free of charge. There is also a Mechanics' Institute, erected by the Company, where lectures on scientific and other subjects of general interest are given during the winter months, with free admittance for the workmen and their families. Four nights in each week are devoted to the classes held under the auspices of the Science and Art Department at South Kensington, and of the Lancashire and Cheshire United Institutes, preference being given to those subjects which have the most intimate relation to the avocations of the men. A circulating library with upwards of 3,300 volumes has been established, and a reading room has been provided, where all the leading newspapers and the best magazines are available for the use of the members. A spacious recreation ground, adjoining the Institute, and covering an area of six acres, contains three bowling-greens, lawn-tennis courts, and a cricket-ground, together with a miniature park tastefully laid out with flower-beds and trees, so that healthful recreation and manly sports are far from being neglected, and, by the liberality of the directors, all these advantages are secured to the men and boys engaged in the works in return for a payment of one penny per week by the men, and one halfpenny per week by the boys.

CHAPTER X.

THE WORKING OF THE TRAINS.

THE immense and continuous development of railway traffic during the last fifty years has taxed to the very utmost the ability and inventive faculties alike of those engaged in its management, and of constructive and mechanical engineers, in order to keep pace with it, and to enable it to be carried on with regularity and despatch, and with a minimum of delays and mishaps. In the foregoing chapters, some account has been given of the numerous mechanical and other contrivances which have been almost universally adopted by railway companies for this purpose; and the following pages will serve to afford an insight into the various administrative arrangements which alone enable the traffic of the chief lines in the country to be carried on. That traffic consists of varying elements. There are express and mail passenger trains, running at a speed of forty-five miles an hour, and, in some cases, more than that; others at a somewhat less speed, but still known as fast trains; stopping trains, calling at every station, and running at a rate of from twenty to twenty-five miles an hour; local suburban trains, running for short distances at a fairly high rate of speed, chiefly for residential purposes; express goods trains between the larger towns, attaining a speed of from twenty to twenty-five miles an hour; slow, stopping, goods trains, for serving smaller towns and villages; and, finally, the heavy coal trains, running out of the great colliery districts to every centre of population. All these various trains, heavy and light, fast and slow, some stopping at the stations and others dashing through them at high rates of speed, have to be accommodated to a great extent upon the same line of rails, yet all to keep their time and fulfil their appointed functions—and, briefly, this is the great problem which railway management has to solve. Such a service cannot be carried on under all circumstances, whether by night or day, in fogs, in snow-storms, in wind or rain, and under all other adverse conditions, without entailing hardships and dangers upon the men engaged in the working; yet it is gratifying to be able to say that the vast army of men of all grades employed in the service of the various railway companies exhibit at all times a state of complete discipline and cheerful devotion to duty, which could not be exceeded by any body of men whatever, and which, although perhaps not so well understood or appreciated by the public as might be the case, reflects the highest credit upon them as a class. Bearing in mind the vast importance of the interests entrusted to their charge, and the serious consequences that might easily arise from any carelessness or dereliction of duty on their part, it is a fact upon which the travelling public may well congratulate themselves, that their lives and limbs, their property and interests are confided to hands so trustworthy and reliable. (See Appendix A.)

The train mileage run upon the London and North-Western Railway during the year ending the 31st December, 1888, was:—

L. & N. W. { Passenger Trains shewn thus ———
{ Goods " " " ———

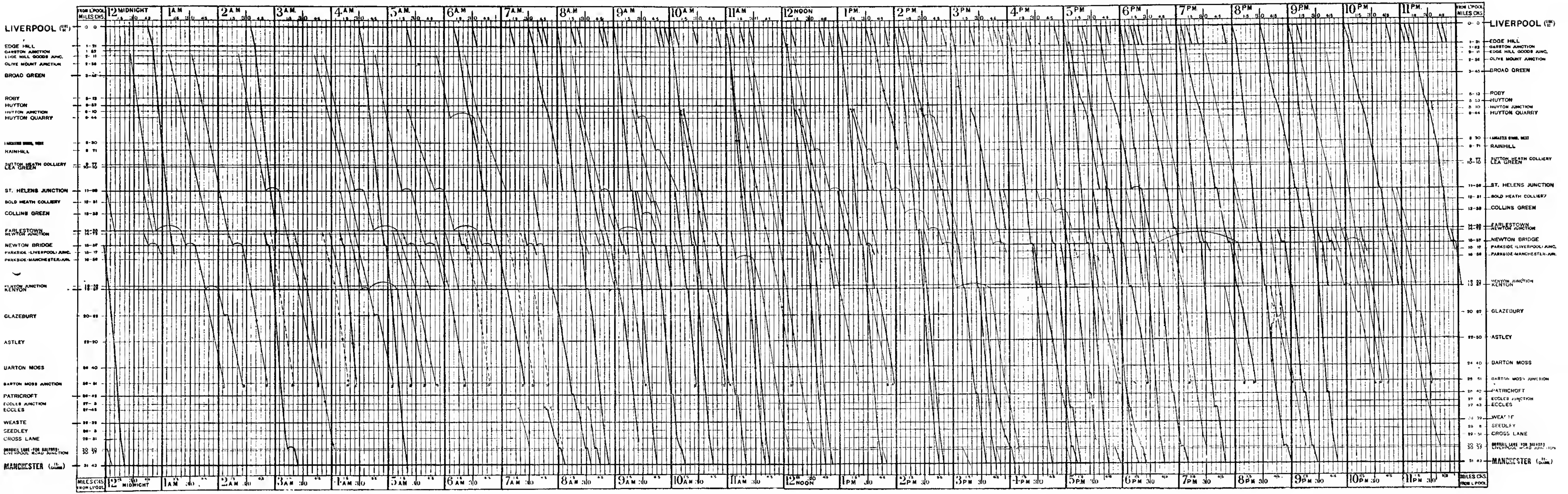
G. W. ... All " " " - - - - - - -

L. & Y.... " " " " "

L. & N. W. R.—DIAGRAM SHOWING THE WORKING OF TRAINS BETWEEN

LIVERPOOL (LIME STREET) AND MANCHESTER (EXCHANGE)

(Via NEWTON BRIDGE)



NOTE Trains shown fine lines, thus ——— run one or two days per week only.
NOTE —Trains marked S come off or go on Slow Lines.
NOTE —Trains marked X, see Liverpool to Manchester, via Wigan, Diagram.

Fig. 26,

Passenger trains	20,001,285	miles
Goods and mineral trains...	19,141,030	"
Total	39,142,315	"

but this was exclusive of empty mileage and of shunting, and, as a matter of fact, the total engine miles run during the year amounted to 55,525,334. In other words, the engines of this one company ran a mile and three-quarters every second, or 104 miles every minute, and in effect they put a girdle round the earth once in every four hours throughout the year, yet such is the perfection of mechanism attained in the present day, that the engines were able to run a distance equal to twice round the world for every single case which occurred of a hot axle, the loss of a split pin or cotter, or anything tending to throw an engine out of gear.

During the year above mentioned, the number of passengers carried on the North-Western Railway was 56,830,216, and the number of tons of goods and minerals conveyed was 35,922,619. The revenue derived from all sources, except from rents, was £4,251,329 from passenger traffic, and £6,198,583 from goods and mineral traffic, giving a total of £10,449,912.

The accompanying illustration (Plate XXVI.) is a specimen on a reduced scale, of the diagrams which are prepared for each section of the line, showing how the engine working is arranged, the time and speed of running, and the intersection of the trains at places where goods and slow passenger trains have to shunt into sidings for the fast express trains to pass them.

It will be perceived that the perpendicular lines divide the day of twenty-four hours into periods of hours, half hours, quarters of hours, and of five minutes; the horizontal lines dividing the railway into sections, while the slanting lines represent the engines or trains timed to run over the line. Thus the diagram offers, as it were, a visible picture of the state of the line, as to its being occupied or otherwise, between any two points at any minute of the day, and it will be easily apparent that such diagrams are invaluable, and in fact indispensable, in arranging train alterations or the running of new trains or special trains when required. The section of line chosen for illustration is that between Liverpool and Manchester, upon the major portion of which there is as yet only one up and one down line of rails, and on this portion one train cannot pass another proceeding in the same direction, unless the first one takes refuge in a siding. Over this Liverpool and Manchester Railway there are running at the present time, for greater or less distances, no fewer than 272 passenger trains, and 292 goods trains, or a total of 564 trains up and down within twenty-four hours. Of the passenger trains, 112 are expresses, fourteen of which travel at a speed of forty-four miles an hour, and the remainder at an average speed of thirty-five miles an hour; and there are 56 express goods trains running at about twenty-three miles an hour.

Over certain busy portions of the North-Western system it has been found necessary, owing to the enormous development of the traffic, to lay down additional lines of rails, and there are now four lines (viz., two up and two down) between London and Roade, between Stafford and Crewe, and over some twenty shorter sections of railway, varying from half a mile to five miles in length, while, on other sections, a third line has been provided for goods traffic only. The advantages of the duplicated lines are obvious; they admit of the fast and slow trains being kept separate, and thus simplify the working, lessen the risk of accident, and reduce delays and irregularities to a minimum.

If the theory of the Time Bill, with regularly appointed trains running at varying rates of speed, with specified places for them to pass each other, could be realised absolutely in regular practice, it would represent the perfection of railway working; but, owing to bad weather, the fluctuations of traffic, the running of special trains at short notice, and other uncontrollable causes, this ideal can never be absolutely attained. The most important thing, at all times, is to keep the line clear for the passenger trains, and, as a matter of fact, everything is made to give way to this, for there is nothing that adds so much to the reputation of a line, or redounds so much to the credit of the officers and servants, as a well-appointed and punctual passenger service. It pleases the travelling public, and brings both reputation and profit to the company.

On a line which is efficiently worked, the percentage of unpunctual trains is small, but at certain times of the year there will always be a considerable amount of late running, which cannot be avoided. For instance, in summer the passenger traffic is largely swelled by tourists proceeding to seaside resorts, the lakes, and Scotland, taking with them great quantities of luggage, which add to the weight of the trains and to the difficulty of getting them away from the stations promptly. Again, in winter, fogs, frosts, and snowstorms delay the progress of cross-channel steamers from Ireland, which run in connection with the trains, and these, in their turn, delay the trains. Those responsible for the working are thus constantly engaged in a contest against disturbing influences, and the arrangements have to be sufficiently elastic to enable trains to be run out of course, if necessary, as safely and well as at the specified times.

Goods trains, starting from terminal stations where the shunting and marshalling of the waggons take place, cannot always leave with absolute punctuality ; nor can those having waggons to attach and detach at roadside stations, where a margin is allowed for the purpose, always accomplish their task within the specified time. The weight of the load, the capacity of the engine, the state of the rails and the weather, the varying gradients, and the more or less frequent running of special trains, are all disturbing elements which have to be reckoned with, and which tend materially to upset the calculations made in compiling the time bill, so that the arrangements for shunting goods trains off the running lines into sidings to allow passenger trains to pass them, have to be left very largely to the discretion of the station-masters and foremen. The most that can be done on the part of the management is to lay down certain rules and principles for the guidance of the men, and this is done. For instance, as a general rule, passenger trains take precedence of goods, cattle, and coal trains, and such trains are not allowed to be started from any station within a given space of time before a passenger train is due. This regulation is, however, subject to modification according to circumstances, and a light through goods or cattle train, on a clear day or night, may be started before a passenger train, if the latter has to call at all the stations. Again, if the station-master or foreman has been informed by means of the telegraph or otherwise, that a passenger train which is due, may not be expected for some time, he may despatch a goods train, taking care to inform the driver of the passenger train when it does arrive, what time the goods train was started, and where it was ordered to shunt. The same principle applies to a slow or stopping passenger train travelling in front of an express which is known to be late.

These are general rules, but on all the more important sections of the main lines it has been found desirable to fix an absolute margin of time within which a goods train is to leave a particular station in advance of a passenger train. This information is set forth, for each division of the line, in what is called the "Working Book," a compendium of general instructions and information issued every month for the guidance of the staff, and which gives also the locality of the various shunting or refuge sidings, and the number of waggons each of them will contain.

The following table, as an example, gives these particulars for down trains on the line from London to Rugby; but, of course, similar arrangements exist with regard to up trains and for all the other divisions of the main line.

But this is not all. To ensure the principal stationmasters and inspectors being kept well posted as to the working of the line and the movement of the trains, a most elaborate system is in force for telegraphing the progress of the trains from point to point. For instance, the telegraph clerk at Stafford will telegraph the time of departure of all trains from Stafford, to Crewe, to Chester, to Wolverhampton, to Tamworth, to Warrington, and to any other stations at which the information is useful, and this is continually going on all over the line, and from almost every station and signal cabin, so that everyone concerned is kept well posted as to what is going on.

DOWN FAST LINE.

Distance from Camden.	STATIONS.	Siding capable of holding	Watford (Junc. from Fast to Slow).	Tring.	Bletchley.	Roade.	Blisworth (Gayton Loop).	Heyford South.	South end Kilsby Tunnel.	Hillmorton.	Rugby.
Miles.		Wgns.	Mins.	Ms	Ms.	Ms.	Ms.	Ms.	Ms.	Ms.	Ms.
4¼	Willesden Junction	...	30	...	...	...	...	...	...	...	...
16¼	Watford (Junc. from Fast to Slow)...	...	...	40	..	...	...	...	...	...	...
30½	Tring	50	...	...	35	...	...	...	...	...	...
45½	Bletchley...	...	...	...	...	25	...	...	...	...	...
58¾	Roade	50	...	...	...	..	15	20	...	...	...
61¾	Gayton Loop	100	...	...	...	...	...	15	...	...	...
66	Heyford (North) ...	160	...	...	...	...	...	...	25	30	...
75	South end Kilsby Tunnel	100	...	...	...	...	...	...	...	20	25
79½	Hillmorton	...	...	...	...	...	...	...	...	...	15

DOWN SLOW LINE.

Distance from Camden.	STATIONS.	Siding capable of holding	Willesden.	Harrow.	Bushey.	Watford.	Boxmoor.	Tring.	Leighton.	Bletchley.	Roade.	Northampton.	Long Buckby.	Rugby.
Miles.		Wgns.	Ms.	Ms.	Ms.	Ms.	Ms.	Ms.	Ms.	Ms.	Ms.	Ms.	Ms.	Ms.
	Camden	...	10	...	...	...	...	...	...	...	...	...	...	...
4¼	Willesden ...	...	...	15	...	...	...	...	...	...	...	...	...	...
10¼	Harrow	45	...	...	15	...	...	...	...	...	...	...	...	...
14¾	Bushey.........	45	...	...	..	10	...	...	...	...	...	...	...	...
16¼	Watford	...	...	...	...	...	20	...	...	...	...	...	...	...
23¼	Boxmoor	50	...	...	...	...	...	25	35	...	...	...	...	...
30½	Tring	50	...	...	...	...	...	...	25	35	...	...	...	...
39	Leighton	80	...	...	...	...	...	...	...	20	...	...	...	...
45½	Bletchley......	...	...	...	...	...	...	...	...	...	25	...	...	...
58¾	Roade	50	...	..	...	...	...	...	...	...	...	15	...	...
66¼	Northampton	...	...	...	...	...	...	...	...	...	...	...	25	...
74½	Long Buckby	50	...	...	...	...	...	...	...	...	...	...	...	25

In order that the different descriptions of trains may be the more readily distinguished one from another, especially at night, a system of distinctive head lights for the engines has been devised, which is as follows :—

1. Engines of Fast Passenger Trains, Fish Trains, and Break-down Van Trains ...	Two White Lights—one over each Buffer. Fish and Break-down Van Trains by day must carry a White Diamond Board over Right Hand Buffer.
2. Engines of Slow Passenger Trains and Light Engines	A White Light over Left Hand Buffer.
3. Engines of "Express" Goods and Through Trains of Cattle, Perishables, and Shipment Traffic	One Green Light over Right Hand Buffer, and one White Light over Left Hand Buffer. A White Diamond Board at Bottom of Engine Chimney during daylight. *See Note A.*
4. Engines of Fast Goods Trains not having to stop at intermediate stations and sidings; also Ballast Trains not stopping to do work on the road	Two Green Lights—one over each Buffer. A White Diamond Board over Left Hand Buffer of Engine during daylight.
5. Engines of Stopping Goods, Mineral, and Ballast Trains	One Green Light over Left Hand Buffer.

Where there are more than two lines (one Up and one Down) a Green Light must be carried at foot of chimney by Engines of all Trains travelling on the Auxiliary Lines.

Light Engines on the Auxiliary Lines must carry one Green Light at the foot of the chimney, the Light on the Buffer Plank being dispensed with.

Note A.—Urgent Express Goods, Cattle, Meat, or Vegetable Trains requiring unusual despatch, will, under special instructions from the District Superintendents, carry the following distinctive Head Signals :—

By day—A White Oval Board, with Green Cross on it, at foot of chimney.

By night—One Green Light over Left Hand Buffer, and one White Light over Right Hand Buffer.

These special Head Signals must only be used in cases specified by instructions from the District Superintendents.

In order to afford some idea of the growth which has taken place in the length and weight of the trains, during the last five-and-twenty years, it may be mentioned that the 10.0 a.m. down express from Euston, which in 1863 was 312 ft. in length, and weighed 123 tons, had increased in 1887 to 652¾ ft. in length, and in weight to 268 tons; while the 5 o'clock train in the evening, in the same period, increased from 403 ft. in length, and 149 tons in weight, to 463¼ ft. in length, and 235 tons in weight. One of the principal up trains from Scotland—the 8.41 p.m. from Carlisle—in 1863 was 206 ft. in length, and weighed 97 tons, while to-day it measures 568¼ ft., and weighs 242 tons (see Fig. 27). Then, again, the speed of the trains has increased to almost as great an extent as their length and weight, for the three trains selected as illustrations travel now from five per cent. to upwards of fourteen per cent. quicker than they did even fifteen years ago.

The London and North-Western Company, however have not hitherto made it their principal object to run their trains at the highest possible rate of speed. In these days, journeys must be accomplished quickly in order to keep pace with the times, and meet the growing requirements of the travelling public; but the highest attainable speed is not always the most compatible with safety and punctuality, and these latter essentials are certainly not the least important to be secured in the working of a railway. Thus the London and North-Western, if it does not lay claim to the doubtful distinction of running the fastest trains in the world, is, it is believed, fairly entitled to the reputation of being the most punctual line in the kingdom. Still it can, on occasion, achieve notable records in the way of fast travelling, and an

FIG. 27.

DIAGRAM OF
LENGTHS AND WEIGHTS OF TRAINS,
L. & N. W. Ry.

320 *feet to* 1 *inch.*
80 *tons* ,,

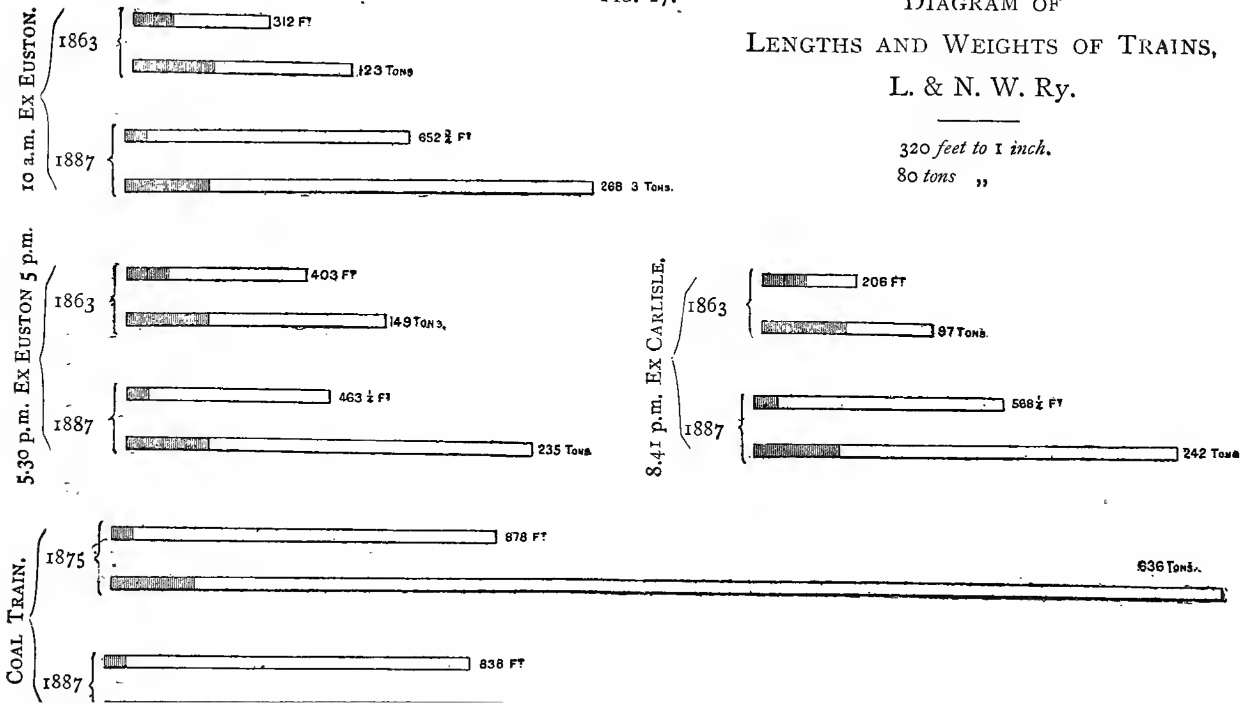


illustration of its ability to do so, occurs to the writer in connection with what happened some years ago, at the commencement of the civil war in America. It was at the time when the British Foreign Secretary had sent a despatch, in the nature of an ultimatum, to the Federal Government, with respect to the case of Messrs. Mason and Slidell, the Confederate Envoys, who had been forcibly taken out of a British ship by a Federal cruiser. There was no Atlantic cable in those days, and although all England was on the tip-toe of expectation to know the terms of the reply which would govern the issue of peace or war between two great nations, there was no quicker means of communication than by steamer to Queenstown, thence by rail to Dublin, then again by steamer to Holyhead, and by rail again to London. During this anxious period from the 2nd to the 9th of January, 1862, an engine was kept constantly in steam at Holyhead, and when at length the long expected despatch arrived, it was brought from Holyhead to Euston, a distance of 264 miles, in five hours, or at an average speed of 53 miles an hour throughout, including one stoppage at Stafford for the purpose of changing engines. It may be added that although at that time the Company had not adopted the block telegraph system, and the working was carried on by the ordinary telegraph signals from station to station, the entire journey was performed without the slightest stoppage or interruption of any kind.

For the working of single lines of railway, most companies adopt what is known as the "Train Staff and Ticket System," which is carried out in the following manner:—Supposing the line, or the section of line, extends from A to B, and there are three trains at A wanting to proceed to B. The first one is despatched with a ticket, and the second also, but the third, or last, must carry on the engine what is known as the train staff, a straight piece of wood somewhat resembling a constable's staff, but coloured and lettered in accordance with the particular section of line it refers to. The box containing the "tickets" can only be unlocked by means of the train staff, which is really the key, and no train can enter the opposite end of the section until the train staff itself arrives at that end, so that it is impossible for two trains to meet in opposite directions, and the proper distance between trains proceeding in the same direction is maintained by fixed signals and the block telegraph, the same as on double lines. Where the branch is a long one, it is divided into sections, with crossing places at convenient intervals, and each section has its own staff and set of tickets, and is worked separately in the manner described.

This system of working single lines, although it has been altered and improved upon in many ways, until it may now be considered to be almost perfect, both as to safety and convenience, was originally devised by Mr. Henry Woodhouse, until lately one of the engineers to the London and North-Western Company, for the working of a long tunnel, called the "Standedge Tunnel," on the Huddersfield and Manchester railway, of which he had charge nearly forty years ago, and was authorised generally by the Board of Trade, and included in their requirements in 1860.

Some single lines of short length, and where the traffic is light, are worked by a single engine in steam, and this fact, of course, supersedes the necessity for any special precautions such as those already described.

Another method of working single lines which has been introduced within a comparatively recent period is what is known as the "Train Tablet System," which is now in operation on a section of the line at Cockermouth, on the Callander and Oban railway in Scotland, and elsewhere. Although the train staff system, as described above, combined with the block telegraph, has answered its purpose well, it has one drawback, which is that the sections have of necessity to be short in order to avoid serious delays, and under any circumstances it may occur that the train staff may be at one end of the section while a train is waiting for it at the other. This fact led one of the officers of the Caledonian Company to set his wits to work to devise an arrangement by which a train staff, or its equivalent in the form of a tablet, or circular disc of metal, could be electrically controlled from the other end of the section, so as to constitute in point of fact a train staff and block telegraph system combined.

The apparatus has been since improved and perfected, and has been patented by Messrs. Tyer & Co., the well-known electrical engineers. Although the working is, in practice, very simple, a detailed description of the instruments used, and the way in which they are manipulated, would appear extremely complicated, but the essential features of the system are as follows:—Supposing A and B are the two ends of a section of single line and a train is waiting at A to proceed to B. The signalman at A gives a signal to that effect on an electric bell to the signalman at B. If, according to the block telegraph regulations, the train may proceed to B, that is to say if the line to the knowledge of the signalman at B is clear between A and B, the signalman at B draws out a slide in his instrument, and depresses a plunger, which, by means of an electric current, has the effect of enabling the signalman at A to draw out a corresponding slide in *his* instrument, and remove from it a train tablet, which he hands to the driver of the train as his authority to start and enter the section in advance towards B. On arrival at B the driver delivers up the tablet to the signalman there, who inserts it in his instrument, *and until this has been done, the apparatus is automatically locked, and a second tablet cannot be obtained from the apparatus at either end.* Thus it is impossible for two trains to be in the same section at the same time, proceeding in opposite directions, although trains may follow one another in the same direction at the proper intervals without intermission or delay.

An apparatus very similar to this, and designed to attain the same objects, has recently been devised and constructed at the Crewe works, and is now in use on the Bedford and Cambridge branch, having been approved by the Board of Trade. In this case train staffs of the ordinary type take the place of the tablets, and these are made in such a form, that they will serve to open any of the intermediate sidings within the section, which in their normal state are loeked. Although the apparatus differs in form, the manipulation is almost identical with that of the train tablet system, it being physically impossible for a staff to be withdrawn without the concurrence of the signalmen at the two ends of the section. The experimental trial of this system having proved very successful, it will probably be extended to other single line branches.

There is one element which causes, perhaps, more difficulty, and entails more anxiety upon those engaged in the management of a railway than all others put together, and that is the prevalence of fogs in this country. When one of these unwelcome visitations descends upon us, although the telegraph still remains, the whole system of visible signals is, as it were, blotted out, and it is easy to realise how extremely difficult this must render the working. The greatest caution has to be observed, the speed has to be reduced, and more or less delay is inevitable in the interests of safety, which, after all is, of course, the first and last consideration. To admit of the trains running while the signals are invisible, a system of what is called "fog-signalling" has been devised, and a brief description of this system, which is as simple as it is perfect, may do much to reassure any of our readers who may chance to find themselves performing a journey by an express train during a fog. At such a time the platelayers are perforce idle, since the permanent way is not allowed to be interfered with until the weather clears, and these men for the most part furnish the ranks of the fog-signalmen. Directly a fog comes on, a man is stationed at the foot of each distant signal, and becomes, in fact, a living signal-post. As soon as the signal-arm is raised to "Danger," he places upon the rails two detonating signals, which are exploded by the engine of a train passing over them, and the driver of the train is thus apprised that the signal, although invisible to him, is at "Danger," and he must act accordingly. If the signal is lowered to indicate that the line is clear before any train approaches, the fog-signalman at once removes the detonators, but replaces them as soon as the signal is again raised to "Danger."

Each man is provided with a hut to shelter him, a fire and a thick warm overcoat, which is supplied by the Company for his use. As soon as he has been on duty three hours he is supplied with refreshments at the Company's expense, and again six hours later if the fog continues so long; and, after twelve hours, if the fog still continues, he goes off duty, and his place is taken by a relief man. The refreshments supplied consist usually of bread and meat, and tea or coffee.

During the week ending the 14th January, 1888, as may perhaps be remembered, occurred one of the most severe visitations of fog within living memory. It was general throughout the country, and, in fact, was not confined to England, but extended over some portions of the Continent. In most parts of the country it commenced either on Sunday night or Monday morning, and, with brief intervals, and in some places with, practically, no interval whatever, it continued until Friday night. It may readily be imagined that to carry on the working of the railway under such circumstances, and for such a lengthened period, became a matter of great difficulty, and imposed a very severe strain upon all the men engaged.

Delays, more or less, were naturally inevitable, but it is gratifying to state that, with the exception of one or two trifling mishaps with goods trains, involving no serious results, the whole of the traffic was carried on during this trying week without any actual interruption, and without accident or injury to a single passenger. This result was entirely due to the efficient carrying out of the system of fog-signalling above described, and probably there could not well be a more searching test of the efficiency of the system employed. Enquiries have shown that during the week in question on the

London and North-Western Railway alone, fogmen had to be provided at 2,462 signal posts; 2,375 men were employed, in addition to 1,377 relief men, making a total of 3,752 men. During the week scarcely any express train was more than half-an-hour late, and some of the trains actually ran to time.

Various plans have from time to time been suggested for dispensing with the fog-signalmen, and conveying to the drivers the requisite warning as to the state of the signals during a fog, by mechanical means, either in connection with electricity or otherwise, and it appears probable that sooner or later some efficient system of this kind will be devised, but, so far, none has been developed which has been thought to be sufficiently reliable, and the matter is still within the region of experiment.

A great deal of difficulty was formerly experienced in getting the fog-signalmen to their posts, especially if the fog came on during the night, as is frequently the case. In remote country districts the men often found it impossible to obtain dwellings near their work, and even in the vicinity of large towns the only houses available were sometimes those of a type unsuited to the means of men of the class to which they belonged. Thus the signalman, confined to his cabin, perhaps in some lonely cutting, far from any station or town, during the solitary hours of the night, would see a fog approach and blot out his signals, and, not daring to leave his post to call assistance, and knowing that the nearest fog-signalman lived a mile, or perhaps more, from the spot, he was frequently placed in a position of great anxiety and perplexity. This difficulty is being gradually met by the expedient of the Company themselves building in the neighbourhood of every station or signal-post where the circumstances are such as to give rise to the necessity, a number of workmen's cottages sufficient to accommodate the platelayers and others who are required for fog-signalling at that particular station or post. These cottages are specially designed for the convenient occupation of a single family; they are of uniform construction, all the wood-work, iron-work, and other fittings being turned out in quantities at the Company's works at Crewe, where the bricks are also made; and owing to this, and to the buildings being erected by the Company's own workmen, they can be completed at a comparatively moderate outlay, each pair of cottages costing from £350 to £400. There is usually an electric bell communication between the signalman's cabin and the bedroom of one of the men, generally the ganger, whose duty it is, on the alarm being given, to call out the other men, so that within a very few minutes of the first warning, every man is at his appointed post, and ready for duty. Both the Company and the men are the gainers by this arrangement. The Company attain their object of having the men concentrated on the spot, and easily accessible at all times, and the rents paid by the men, which range from 2s. 6d. to 3s. per week, ensure them a certain return, although a small one, for their outlay. The men, on their part, reap the benefit of occupying, at a small rental, a commodious and convenient dwelling, near to their work, constructed under proper sanitary conditions, kept in a good state of repair, and in every way infinitely superior to the best accommodation which their small means would otherwise enable them to obtain.

Besides the cottages for fog-signalmen, the Company provide houses for their station-masters, foremen, signalmen, engine-drivers, brakesmen, and others, who cannot easily obtain suitable dwellings near the stations to which they are attached, the houses owned by the Company and occupied by their servants, being in all nearly 4,000 in number.

It is only during the passage of the Royal train to convey Her Majesty and suite to and from Scotland twice a year, that the ordinary arrangements for working the line are suspended. The exceptional nature of the regulations then adopted may be considered as affording the nearest approach to perfection in railway travelling that has yet been arrived at. The train is lighted with gas, and fitted throughout with the Westinghouse and vacuum brakes, with an electrical communication between the compartments of each saloon and carriage, and the guards, and with a communication between the front guard and the driver. A pilot engine is run fifteen minutes in advance of the train throughout the entire journey, and in order to guard against any obstruction or interference with the safe passage of the train, no engine, except the pilot, or any train or vehicle, is allowed to proceed upon or cross the main line during an interval of at least thirty minutes before the time at which the Royal train is appointed to pass. All shunting operations on the adjoining lines are suspended during the same period, while, after the Royal train has passed, no engine or train is permitted to leave a station or siding upon the same line for at least fifteen minutes. In addition to these regulations, no engines or trains, except passenger trains, are allowed to travel between any two stations on the opposite line of rails to that on which the Royal train is running, from the time the pilot is due until the Royal train has passed. For instance, supposing the Royal train is to run on the down line from Stafford to Norton Bridge, and the pilot is due at Norton Bridge at, say eight o'clock, if a goods train or light engine required to travel on the up line from Norton Bridge to Stafford, and it was ready to start at eight o'clock, it would be kept back until the Royal train had passed.

The precaution is also taken of specially guarding every level crossing, farm crossing, and station, to prevent trespassers, and of securely bolting all facing points over which the Royal train must pass. Platelayers are also posted along the line to prevent the possibility of any obstruction or impediment occurring; and all level crossing gates, where gatekeepers are not kept, are locked an hour before the train is due, and kept so until it has passed. Special arrangements are made for telegraphing the passage of the train from point to point as it speeds along its journey, and an instrument is conveyed by the train by means of which a telegraphic communication can be established at any place on the journey in case of need. The train is accompanied by a staff of fitters, lampmen, and greasers, who keep a vigilant watch on each side of it, so as to notice any irregularity in the running of the carriages, and who, upon the train stopping at the appointed stations, examine it throughout and grease the axle boxes. The average speed of the train does not exceed about thirty-six miles an hour excluding stoppages.

CHAPTER XI.

THE SHUNTING AND MARSHALLING OF GOODS TRAINS.

IN working the goods traffic on a line such as the London and North-Western, the trains are so arranged as to run with full loads between the most important points, as from London to Birmingham, Liverpool, Manchester, Scotland, and so on; but the traffic at the intermediate stations is collected by a service of local stopping trains, and conveyed to the large junctions, such as Rugby, Crewe, and Stafford, where the waggons are properly classified and marshalled for transit by the through trains. This operation of marshalling and classifying the goods and mineral traffic into district and station order, as will be readily believed, is one of immense magnitude and difficulty, and the work at the terminal stations, and at the important junctions, is extremely complicated, and carried out at a great cost. It is obvious that, unless the trains were properly marshalled for their various destinations, and the waggons arranged in station order, it is not enough to say that the traffic could only be carried on with the most serious interruption and delay; but it would, in fact, be impracticable to carry it on at all, now that it has attained its present dimensions. As it is, any neglect or omission on the part of the men employed in this duty results in great confusion and difficulty at the junctions and stations, as the train proceeds on its journey. The extent of the operations required may be gathered from the fact that the London and North-Western Company alone have no less than 228 engines constantly employed in this work of marshalling and classifying the trains in the sidings, and that the total number of hours of shunting performed last year by these engines was estimated at 1,989,751, representing a cost to the Company, at 5s. per hour (including wages), of £497,437.

The great importance of performing this work in an effectual manner, and with the minimum expenditure of time and money, has led to the subject being studied and debated perhaps to a greater extent than any of the other problems which railway management has had to deal with. Many plans have been suggested and put in operation, as, for instance, at Camden, where the sidings are laid in parallel lines, with a double line of turn-tables across them, worked by hydraulic capstans; at Willesden, Stafford, and other places, where there are sets of sidings in the shape of a fan, with a shunting "neck," or siding, which represents the handle of the fan; and at other stations where the fan-shaped sidings are adopted, but with a falling gradient, utilised so as to economise power. The "fan" arrangement, either with or without the aid of gravitation, is the one most commonly in use, and its utility is sufficiently apparent if the nature of the operation required to be performed is borne in mind. By its aid a miscellaneous collection of waggons for different destinations can be broken up into sections, each section being placed either by gravitation, by a shunting engine, or by horses, in a separate siding. All the sidings running into a common departure line, it is obvious that the sets of waggons can then be drawn out in any order in which they are required to be marshalled in the trains.

At certain important places throughout the country, as at Shildon, on the North-Eastern Railway; at Chaddesden, near Derby, and at Toton, near Trent, on the Midland Railway; and at Blaydon, near Newcastle, on the North-Eastern, and elsewhere, schemes of marshalling sidings of elaborate construction and great extent have been laid down, and these have in each case their own distinctive features, but they have for the most part been devised to meet the special circumstances of a particular traffic or locality, and probably it is not necessary to enter into a detailed description of them. The most successful experiment which has been tried upon the London and North-Western Railway, and possibly also the most successful in the kingdom, whether with regard to efficiency or economy, has been an ingenious plan devised by Mr. Harry Footner, M.I.C.E., one of the Company's principal engineers, for marshalling the waggons in *district* and *station order* by one operation, and by means of gravitation. This plan has been put in operation on an extensive scale at Edge Hill, near Liverpool, and as it is one which would be applicable to any large station or junction where a great number of waggons required to be sorted and marshalled, and where a suitable gradient either naturally existed, or could be easily obtained, a description of the method in which the work is carried on and the results obtained, may not be without value.

Edge Hill, as is no doubt well known, is a place on the outskirts of Liverpool, and is situated on the Liverpool and Manchester Railway, which, as we have seen in an earlier chapter, was the first railway constructed by George Stephenson, nearly sixty years ago. At this point the Liverpool and Manchester Railway, which has its passenger terminus at Lime Street, a mile and a quarter from Edge Hill, is joined by a branch railway running round the city, to the docks at the north end, and also by branch lines running through tunnels, under the city, to the various goods depôts at Wapping, Waterloo, and Crown Street, so that it will be easily perceived that as regards goods traffic, Edge Hill is a very important and busy place indeed. This is sufficiently proved by the fact that, at the present time, no less than 534 trains of all descriptions are running in and out of Edge Hill within 24 hours, viz., 273 in, and 261 out, and that it has been found necessary to build there a steam shed or engine-house, which holds eighty engines.

Of course, all goods trains arriving at Liverpool have to be broken up at Edge Hill, and the waggons have to be sorted out for the several depôts, whence they are distributed to the various docks and warehouses. On the other hand, the trucks loaded at all the depôts have to be sent, in the first place, to Edge Hill, where they are classified and marshalled in trains for despatch in all directions. These comprise what is called the "outward" traffic.

It was about the year 1873 that the Company began to have strongly impressed upon them the urgent necessity for making provision on a very much larger scale than they had, up to that time, contemplated, for the shunting and marshalling of trains at Edge Hill, and that they commenced to carry out, as an experiment, and, to a limited extent, the system which has since been elaborated and extended with such beneficial results. In that year (1873) they found themselves in presence of this state of things—that, while the outwards traffic at Edge Hill had grown from 257,025 tons in 1850 to 1,032,853 tons in 1873, the siding accommodation had only been increased from 1,782 waggons to 3,215 waggons; in other words, the business had quadrupled, while the facilities for dealing with it had only been doubled. It may here be said, that, at the present time, the area occupied by shunting lines and sidings at Edge Hill is 200 acres, and that there are 57 miles of running lines, and siding room for nearly 6,500 waggons.

At the period mentioned it became necessary to consider seriously how the difficulties were to be met, for, in addition to the want of room, the main passenger lines had to be crossed every time waggons were moved from one group of sidings to another (and there were a great many groups), so that there were serious obstacles to be encountered in carrying on the working, and as the safety of the passenger trains always had to be the first consideration, the goods traffic had often to suffer delay.

The Company had, at that time, about 70 acres of spare land on the north side of the railway, and available for extension, but to reduce this to the level of the main lines would have involved a stupendous amount of excavation, and the fact that the surface of the land rose from west to east, and that, for a comparatively reasonable outlay, sidings could be laid upon it on a uniform gradient which would enable them to pass *over* the branch line running round to the docks, which branch line intersected the land, suggested to Mr. Footner a scheme for marshalling by gravitation. In considering a scheme of this kind two things appeared to be essential—first, that in the passage of the trucks

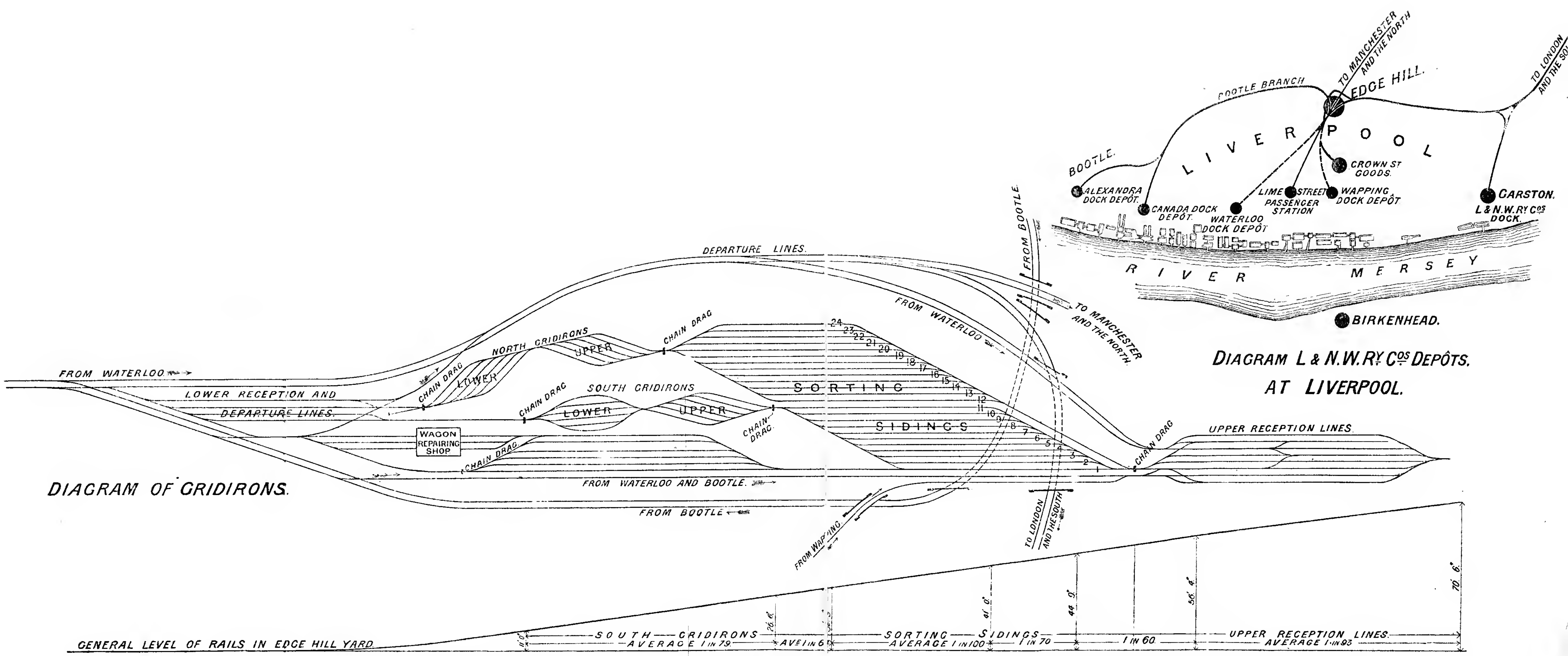
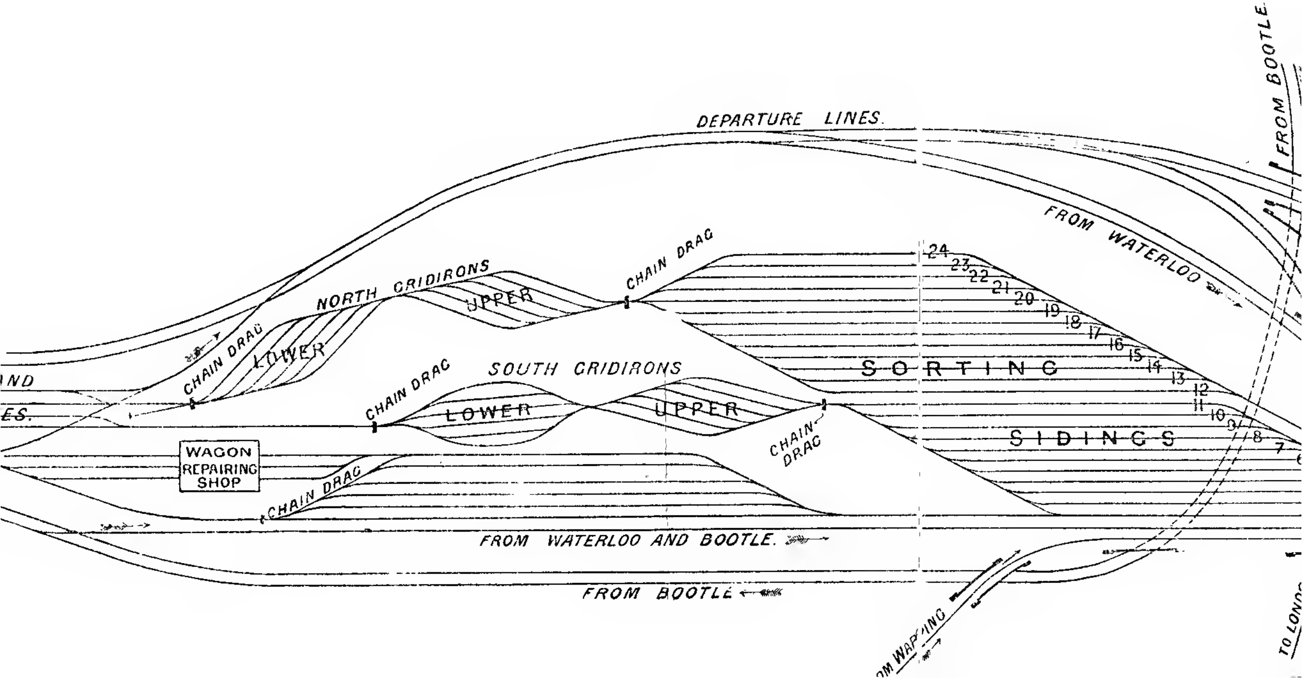


DIAGRAM OF GRIDIRONS.

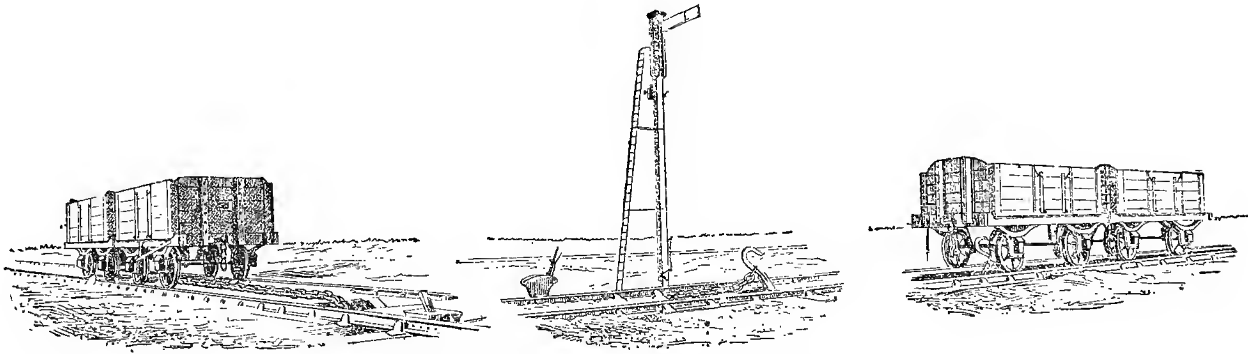
DIAGRAM L & N.W. Ry Cos DEPÔTS. AT LIVERPOOL.

FIG. 28B.


DEPARTURE LINES.
FROM BOOTLE
FROM WATERLOO
NORTH GRIDIRONS
CHAIN DRAG
UPPER
CHAIN DRAG
LOWER
SOUTH GRIDIRONS
CHAIN DRAG
LOWER
UPPER
CHAIN DRAG
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
SORTING
SIDINGS
WAGON REPAIRING SHOP
CHAIN DRAG
FROM WATERLOO AND BOOTLE.
FROM BOOTLE

from the top to the bottom of the incline, all the necessary changes in their relative positions should be effected, so that when they reached the bottom they should be ready to go away as properly marshalled trains; and secondly, that there should be some means of stopping, without injury to them or their loads, any trucks which might get beyond the control of the shunters. The mere principle of shunting by gravitation was no new thing, as it had already been successfully adopted for coaling ships on the Tyne, and for sorting mineral trains at Darlington on the North-Eastern Railway; but Mr. Footner claims as his own the idea of an inclined plane specially constructed in such a way as to *sort and marshal* a mixed goods train by gravitation alone, without any assistance from locomotive or horse power.

The arrangement he devised is shown by the accompanying diagram (Fig. 28 B). The sidings consist of, first, the six upper reception lines at the summit of the incline, holding 294 waggons; secondly, the sorting sidings, 24 in number, and capable of holding 1,065 waggons, into which the waggons, when separated, first run, each siding receiving the waggons for a particular *train;* thirdly, two groups of marshalling sidings, which owing to their peculiar formation have been christened "gridirons," through which the trucks are filtered so as to make them take their proper order of precedence in the train; and, fourthly, the lower reception and departure lines, which receive the trains in their complete state, and where the engines are attached to take them away. All these, it may be remarked, are laid out in such a manner, with a view to future requirements, that without altering any of the existing lines



SKETCH OF CHAIN DRAG AND HOOK.

FIG. 28 A.

EDGE HILL MARSHALLING SIDINGS.

the accommodation can be increased, when necessary, by 50 per cent.

The *modus operandi* is as follows:—On the arrival of a set of waggons in the upper reception lines, the rear brakes are put on, the engine is detached, and then on each waggon is chalked the number of the sorting siding it has to enter. One man carefully inspects the brakes of each waggon, and calls out the chalked number to a second man standing below him, who has to regulate the speed of the descending waggons. This second man passes the number on by hand signal to the shunter lower down who has charge of the points, and who, by moving a lever, turns the waggon into its proper siding. The shunters are provided with brake sticks, which they insert between the wheel and the waggon-frame to steady the waggons in going down, and they also use these implements for letting down the brake levers when required. By the process thus described, each sorting siding now holds a separate train, although the waggons composing it are in indiscriminate order, but by a repetition of the operation, the waggons of each train are separated in the gridirons, and are lowered, one by one, into the departure lines, in the precise order in which they are required to be sent away.

Fig. 28 A also shows the apparatus known as the "chain drag," devised by Mr. Footner for arresting runaway waggons, which may occasionally get beyond the control of the shunters. This consists of a heavy iron chain cable, placed in a wrought iron tank between, and below, the level of the rails; a steel hook attached to the cable is fixed in a loose socket, at the height of a waggon axle, and is worked by a lever which also works a signal.

When a train is intended to pass, the hook is lowered by the lever, but if it is desired to stop a waggon, the hook is raised by the lever, and catches the axle of the waggon, and the heavy cable attached to the hook, being drawn out of the tank, by its weight, when dragged over the ballast, soon stops the runaway. During the last twelve years this apparatus has come into use 135 times, and in no case has it failed to stop the waggons, without injury either to them or to their loads, or to the apparatus itself. At the present time there are six of these chain drags in use at Edge Hill, the cables varying in weight from 86 cwt. to 109 cwt.

The gradient of these sidings varies, according to requirements, from 1 in 60 to 1 in 115. For instance, through points and crossings, and round the standard curve of seven chains radius, the gradient is from 1 in 70 to 1 in 100, but on straight lines, where waggons have to start singly, and enter curves, as, for example, at (1), the lower end of the upper reception lines; (2) the lower end of the sorting sidings; and (3) the lower end of each siding in the gridirons, the gradient is one in 60. Again, on straight lines, where many waggons move together, and good "runners" compensate for bad, the gradient varies from 1 in 100 to 1 in 115. All the curves are of the same radius (seven chains), so that a shunter, in determining the speed necessary for any particular truck, may concentrate his attention upon it, knowing that the resistance of every curve it encounters will be the same. Speaking generally, the gradients are so regulated that the greatest momentum is imparted where the trucks are required to start quickly, and where there is the greatest amount of resistance to be overcome

In practice it is found that in shunting by gravitation, no two trucks run exactly alike, some railway companies and private owners keeping their stock in better order than others, and much depending upon the precise condition of the tyres and axle-boxes, the length of the wheel base, the nature of the load, and the description of brake gear employed. Strong winds also affect the running, especially of covered vans lightly loaded; severe frost offers an impediment, while, on the other hand, warm and moist weather renders the rails slippery, and heavy concentrated loads on a narrow wheel base will often run too freely; but there are simple appliances which are found in practice easily to overcome all these difficulties. The shunters, during the day-time, use various recognised gestures to indicate in advance to one another the numbers chalked on the trucks passing down the incline, and during the night, similar information is communicated by the movement of the coloured lenses of their hand-lamps.

During the year 1887, 518,000 loaded waggons were passed through these sidings, in addition to 108,000 empty waggons, making a total (exclusive of special trains) of 626,000 waggons, or a daily average of about 2,000, equal to fifty average trains.

There are eighty-three men employed to work the sidings, including nine foremen and inspectors. The various foremen's offices are connected by telephone circuits, and, finally, the whole of the sidings are lighted by lofty and powerful lamps of the Siemen's type, in addition to smaller lamps fixed near each pair of points.

One special advantage claimed by its inventor for this system of marshalling waggons, is that it can be carried out by any active man without previous training, the operations being so simple that the work can be learnt in a week or two, and the only man who is really required to be possessed of geographical knowledge and experience being the one who chalks the numbers of the sidings on the waggons.

CHAPTER XII.

ON THE WORKING OF GOODS STATIONS.

TO the uninitiated, it may possibly appear that when a package or a consignment of merchandise is handed to a railway company for transit, it is a very simple operation to place it in a waggon and convey it to its destination, but it is only necessary to bear in mind the vast extent of the operations carried on at a large and important goods station, the multitude of consignments that have to be simultaneously dealt with, their varied description, and the many destinations to which they have to be conveyed, in order to realise that to enable a vast business of this kind to be conducted with promptitude and certainty, to provide securities against goods being mis-sent or wrongly delivered, and to ensure a reliable means of tracing them in the event of their, after all, going astray, a most complete and careful system of organisation is indispensable. It may be premised that the methods and appliances employed by different railway companies, as a means of securing these results, are not precisely identical in practice, nor are they absolutely uniform at all the stations of one company, it being frequently necessary to be guided by physical circumstances, the mode of construction of the premises, and the special nature of the traffic at particular stations, but from a description of the mode of working certain of the goods depôts on the London and North-Western Railway, the reader will be able to gather a fair idea of the nature of the operations to be carried on in working a large merchandise traffic, and of the arrangements which, with more or less variation, are adopted at the most important goods stations.

A goods station which possesses certain features of interest, chiefly on account of its somewhat unique mode of construction, is Broad Street, which is the City Depôt of the London and North-Western Company, in London. The North London Railway, which is connected with the North-Western, passes round the Northern suburbs of London to Dalston Junction, where it trends almost due South to its passenger terminus at Broad Street, in the very heart of the City. Land in the City of London being, of course, extremely valuable, the line is carried during the latter part of its course by means of bridges and viaducts at a high elevation, in some cases over the tops of the houses, and it thus reaches its terminus at a point considerably above the level of the surrounding thoroughfares, the passenger station having accordingly been built on arches. Advantage has been taken of this fact to enable the London and North-Western Company to provide themselves with an extensive goods station without incurring the enormous expense of taking land for the purpose in the busiest part of the City, and the goods traffic is, as a matter of fact, conducted in the arches under the passenger station, the waggons of goods being transferred one by one from the upper to the lower level and *vice versâ*, by means of powerful hydraulic lifts. All along the front of these arches, which are fourteen in number, and, including some space beyond them, which has been covered in, each measure 340 feet in length, and 32 feet in width, a roomy stage, or unloading bank, has been erected, 430 feet long and 45 feet deep, and from this, at right angles, narrow stages 240 feet in length, and 12 feet in width, with a line of rails on each side of them, extend through each arch, the lines of rails being at the further end connected with a cross-line, by means of which the waggons can be turned upon turn-tables, and taken to one or other of the hydraulic hoists, each of which will raise a weight of fourteen tons.

On the further side of the arches some additional space has been taken in on the street level to form an open goods yard, on one portion of which a lofty warehouse has been erected for the storage of goods waiting delivery, or goods for forward transit.

Before attempting to describe the manner in which this station is worked, it is necessary to explain that traffic arriving from the country for delivery in London is called "up traffic," while "down traffic" means traffic sent from London to the country, and these two elements in the business of the station are in practice kept perfectly distinct.

The inwards or "up" traffic at Broad Street, consists very largely of provisions for supplying the early markets with fish, meat, poultry, butter, eggs, and other perishable commodities, which have to be delivered in time for sale to the retail buyers who attend the markets as early as four o'clock in the morning, and also of general merchandise, purchased from manufacturers in the provinces one day, and expected to be in the City warehouses by nine o'clock on the following morning; and to effect deliveries at such an early hour is a work which demands for its accomplishment the most perfect organisation and attention to detail. For instance, in the Metropolitan Meat Market there are no less than 230 stalls or shops, all of which receive meat from the provinces, and the railway companies are expected to deliver and *hang* the meat in these shops before the arrival of the salesmen. Thus, a waggon will arrive, say, from Scotland, with thirty sides of beef for delivery to as many consignees, in as many different parts of the market, while other meat will arrive simultaneously from other stations for the same consignees, and, with a view to speed and economy, the different consignments have to be brought together, and the vans loaded in such a way that, as far as possible, two vans will not be delivering at the same time to one shop. This is effected by sorting the meat into districts, according to the position of the stalls in the market, on the stage at Broad Street before it is loaded on to the vans.

Speaking more generally, the mode of dealing with "up" goods is as follows:—This part of the business is conducted, not in the arches previously described, but in the warehouse of which mention has already been made, the ground floor of which is staged, so as to form a deck, or platform, upon which the goods can be sorted and transferred from the railway waggons to the street vans. This platform is open on both sides, so that vans can be backed up to it on one side, while a line of rails extends along the other side, on which the railway waggons on arrival are placed, after being lowered from the upper level by means of the hydraulic hoists. The invoices which are received with the waggons, and which are documents containing a description of the goods, their marks and addresses, the weight, and particulars of the charges, are passed into an office called the delivery office, where each invoice is entered in a book, stamped with a progressive number, timed as to arrival, checked as to correctness of rate and charges, and is then passed to a "marking clerk," whose duty it is to mark against each entry on the invoice the position on the platform or sorting bank in which the article to which the entry refers, is to be placed. On the platform, by means of letters and numbers painted on the columns which support the roof, the whole of London is mapped out into districts with great care and precision, and the numbers inserted by the marking clerk on the invoice correspond with these divisions, and are for the guidance of the checkers in unloading the goods from the waggons, and loading them into the vans for delivery. The marking clerk having discharged his office, the invoice passes on to another set of clerks, each of whom extracts from it, and enters on the carman's delivery sheets, such of the entries as refer to the particular section of the City with which he is appointed to deal, and by this process of exhaustion, the whole of the entries for delivery to a particular district are brought to a focus, although the goods may have arrived from hundreds of different stations, and be entered on as many different invoices. The same set of clerks enter the charges in the carmen's delivery sheets in cases where they are to be paid by the consignees.

The next step is to pass the invoice out of the delivery office to the platform, where a gang of men unload the goods from the waggons, checking them with the invoice as they do so, and wheel them away on hand-trucks to the different positions on the platform, according to the numbers marked against the entries. Next, the carmen's delivery sheets are passed out to the platform, and the delivery foreman directs the loading of the vans from the different sections on the bank, the goods being carefully checked against the entries on the delivery sheets as they are placed in the vans. Finally, the cartage department take possession of both vans and delivery sheets, the vans are horsed and started away to their respective destinations, all the processes being carried out with the utmost care, but at the same time, with the greatest rapidity.

There are, however, many contingencies which arise in the working of the traffic, and must be promptly met, in order to prevent delays occurring, and the chief of these may be classed under four heads, as follows :—(1) Goods arriving without invoice; (2) discrepancies between the invoice and the goods actually received in the waggons; (3) invoices arriving without the goods; and, (4) goods accidentally trucked to the wrong position on the platform.

If the waggon arrives without invoice it is unloaded in its turn, an account of the goods contained in it is entered on a special form provided for the purpose, and, where the addresses of the consignees appear on the goods, they are trucked away to their proper position on the platform, the number of the section being marked on the form by the checker. The form is then passed into the delivery office, and, as far as possible, delivery sheets are made out from it in the same way as if it were the missing invoice. Such goods as are found in the waggon merely under mark and not addressed, are taken to a particular position on the platform to wait further orders on the arrival of the invoice. Meanwhile the sending station is applied to for a copy of the invoice, and the goods which remain on hand are dealt with on its arrival. A similar course is adopted in the case of goods found in a waggon without there being any corresponding entry on the invoice.

When the invoice arrives, but not the goods, which usually results either from the waggons having been wrongly labelled or having missed their proper train, the telegraph is set to work to ascertain their whereabouts, and the invoices are held over until the goods make their appearance.

The most troublesome errors arise from the porters misunderstanding the directions given by the checkers, and wheeling goods to a wrong section on the platform. In a case of this kind, when the delivery sheet for that section arrives from the office, it, of course, contains no entry of this particular package, and it is consequently left on the bank. On the other hand, the checker for the section to which it should have been taken finds he is short of it, and makes a remark to that effect on the sheet which he passes back to his foreman, and the latter employs every means in his power to discover the whereabouts of the missing package. Failing to do so, he calls in the services of two men, who are called "searchers," and are employed upon this duty all day, but if their efforts prove fruitless there is nothing for it but to wait until the "bank list" is taken, that is, when at four o'clock each afternoon a complete list is made of all goods remaining on the bank after the morning's deliveries, by means of which most errors can be rectified.

The "down," or outward traffic is dealt with in the arches before described, the "runs" or lines of rails alongside the stages being gradually filled during the day with rows of empty waggons, ready to receive the goods as they come in during the afternoon and evening. This is effected by transferring to the "down" arches the waggons which have come in with "up" goods and have been emptied during the morning. As the loaded vans come in at the gates they are stopped at an office placed at the entrance, called the "weigh-bridge office," and the consignment notes are impressed with an official stamp, which alone renders them authentic. The consignment note plays an important part in the manipulation of the outwards goods, and it may be explained, for the benefit of the uninitiated, that it is a document which the sender of goods hands to the carman or other agent of the Company, to whom he delivers the goods, and in which is described their nature, their marks, and addresses, and sometimes their weight. Business firms who are in the habit of forwarding goods use for this purpose printed forms supplied by the Company, or provided by themselves, but where ordinary members of the general public forward isolated packages without a consignment note, the Company manufacture one from the address, or the entry in the carman's book, the principle acted upon being that there must be a separate consignment note provided for every distinct package or parcel of goods for the same destination. The object of stamping the consignment notes at the entrance gates is to checkmate a very ingenious system of fraud which was found to be in operation some time ago, when some dishonest servants of the Company hit upon the plan of obtaining possession of valuable goods, by simply destroying the original consignment notes and addresses, and substituting false documents, by which the goods were consigned to confederates in some other town. Under the present system, as the fraudulent note could not bear the weighbridge stamp, its character would at once be detected.

Large firms frequently enter a whole van load of goods for various addresses, on one consignment note, and therefore the first step is for all such notes, containing more than one entry, to be taken to an office called the "Shipping office," where a separate note is made out for each separate consignment, these manufactured notes being officially stamped to shew that they are "extracted" from an authentic note.

Meanwhile the vans, as they arrive, are placed in position for unloading on to the large stage or platform, previously described as running along the front of all the arches; the consignment notes relating to each load are handed by the unloading foreman to the various checkers who are in charge of the unloading gangs, and the goods are removed from the vans, checked against the entries on the consignment notes, and weighed on the weighing machines, which are stationed at regular intervals all along the stage. On the wall in each of the arches is painted a number, and the name of the place or district for which goods are loaded in that particular arch; for instance, one will be "Liverpool," another "Manchester," a third "North Staffordshire," and so on, and in each arch, also, there is displayed a copy of a table, corrected from time to time, and which shews in more detail the stations to which goods are loaded in each arch, and the times of departure of the trains made up and despatched each night to the various destinations. The experienced checker, however, has all this in his head, so that when a package is taken out of a van, and the marks or address is called out, he is able at once to check the entry on the consignment note and to shout "No. 5," or "No. 6," as the case may be, when the package is forthwith placed on a hand truck and, accompanied by its consignment note, is wheeled away to the particular arch to which it belongs, and deposited on the stage there, ready for loading into the waggons. Here one of the loading gangs, each of which consists of a checker, a loader, a caller-off, and two porters, take it in hand, and deposit it in a waggon destined for the station to which it is addressed. When the goods are in the waggons, the consignment notes are taken to the shipping office, and the clerk in charge sorts them out to the different clerks whose duty it is to make out the invoices for the various destinations. These clerks enter on the invoices the names and addresses of consignees, the nature and description of the goods, the weight and the charges; and the invoices, if they are ready in time, are handed to the brakeman in charge of the train by which the waggons are despatched; if not ready at the time the train departs, they are sent afterwards by fast passenger trains, so as to arrive at the same time as the goods, or before. The consignment notes, having been marked with a progressive number in such a way as to identify them with the corresponding entries on the invoices, so as to facilitate the tracing of goods which may go astray, are carefully filed for future reference.

The waggons of goods when loaded, sheeted, and labelled, are run out at the further end of the arches, turned on to the hydraulic hoists by means of the turntables and capstans, and emerge on to the upper level, where in a group of ten long sidings adjoining the North

London Railway, and still by the aid of hydraulic capstans, they are marshalled into trains, and sent away to their various destinations.

This process is, however, very much facilitated beforehand by the fact that the waggons have been arranged in the runs or arches in *train order*, *i.e.*, a separate train or portion of a train has been loaded in each arch and in station order, so that the waggons emerge from the lifts on the high level in the order in which they are required to go away.

Goods intended for large cèntres such as Liverpool, Manchester, etc., to which many waggons are loaded on the same night, are dealt with in two of the arches which are laid out in a somewhat different manner from the rest. In these arches, there is a roadway for carts throughout, and the goods are loaded direct from the carts to the railway waggons without any hand trucking being needed.

If, through extra pressure, or by oversight, goods are left on the stages when the loads have been made up, and the night's work is over, the consignment notes found with them are taken into the shipping office, and stamped with the letter " S " (Stage), to indicate that the goods have been left over, and that special attention must be given to their despatch by the first available train.

When goods are found left on the stage without consignment notes, if the names and addresses of consignees are apparent, they are entered on new consignment notes, and dealt with in the usual way. If, on the other hand, there is nothing to indicate their destination, they are kept on hand, and a record of the fact is made in a book set apart for the purpose, and which is referred to whenever there is any enquiry with regard to goods not delivered, every available means being meanwhile taken to discover the owners, by a number of clerks specially employed on this duty.

There are many other arrangements in operation, both with regard to "up" and "down" traffic, with a view to guard against irregularities, and to rectify mistakes; but perhaps enough has been said to give an adequate idea of the amount of method and organisation required to conduct such a business with order and despatch.

The warehouse, already referred to, which occupies one side of the yard, and rears its imposing height far above most of the surrounding buildings, consists of four storeys, besides extensive cellarage in the basement, and the different floors are reached from the stage by means of two 25-cwt. hydraulic lifts. Packed closely from top to bottom with goods of every possible description, it would at first sight appear that an individual package once deposited here, would be to all intents and purposes lost, but a brief examination will correct this error, and reveal order in the apparent chaos, for the numerous iron pillars which support each floor divide it into small sections, each of which bears a number, while every article which comes into the warehouse, either waiting for delivery, or for forward transit, is entered in a book with the number, against the entry, of the floor and section in which the article is deposited. Amongst a great deal of curious flotsam and jetsam, which has drifted into this capacious repository, perhaps one of the most interesting features is a huge wooden case, fashioned after the manner of a coffin, and which contains what are alleged to be the fossilised remains of a gigantic specimen of the human race, upwards of twelve feet in height, and of colossal proportions. It is said to have been excavated near the Giant's Causeway (surely an appropriate spot for such a *trouvaille!*), some years ago, during some prospecting operations for the discovery of iron ore, and was for a time exhibited at Liverpool; but a dispute arising as to its ownership, the grim relic was thrown into Chancery, and has remained "on hand" at Broad Street ever since the year 1876, the Railway Company having a very considerable lien on it for warehouse charges. Whether it be, as stated by its original owner, the petrefaction of a human being, or merely a specimen of very antique sculpture, it is beyond doubt one of the most curious consignments ever warehoused by a railway company.

The total area embraced by the Broad Street Goods Station, including three and a half acres on the high level, is seventeen acres, the lines affording, in all, standing room for 820 trucks, of which 487 can be placed in position for forward loading on the low level at one time. On the average, 456 loaded waggons are received daily, and 508 are forwarded, making a total not far short of a thousand waggons a day.

The crane power employed is as follows:—

Nine 30-cwt. hydraulic cranes, and twenty-seven manual cranes, for loading from vans to waggons and *vice versâ.*

Eleven 30-cwt. hydraulic cranes, and five manual cranes, for loading from vans to platforms and *vice versâ.*

Twenty 30-cwt. hydraulic cranes, and sixty-nine manual cranes, for loading from waggons to platforms and *vice versâ.*

Besides which there are twelve hydraulic and twenty-eight hand cranes used for special purposes, and one 5-ton and one 10-ton hydraulic crane in the yard, for dealing with exceptionally heavy articles.

A goods station of the London and North-Western Company, which has excited the attention, and, to some extent the admiration, of foreign engineers and railway managers who have visited this country for the purpose of comparing their own methods and appliances with ours, is Holyhead. The Company have devoted a great amount of attention to cultivating and encouraging the trade between England and Ireland, and one means to this end has been the provision of very complete and admirably adapted accommodation at Holyhead, for the transfer of traffic between the railway waggons and the fleet of steamers belonging to the Company, seventeen in number, and having a gross tonnage of 6,128 tons, by means of which a daily service is established between Holyhead and the North Wall, Dublin.

Holyhead Harbour, the entire quay frontage of which is about 3,760 feet, has an area of twenty-four acres, and an average depth at high and low water of thirty feet and twelve and a half feet respectively, the transhipment of the goods being carried on in two large warehouses, each about 750 feet in length, erected on the quays on the east and west sides of the harbour, of which the one on the east side is devoted exclusively to the export traffic, or traffic going from England to Ireland, and the one on the west side to the traffic from Ireland to England. Lines of rails, conveniently connected with the railway, run right through both warehouses, with a platform or loading deck, fifteen feet wide, running throughout between the lines of rails and the quay. In each warehouse there are six hydraulic cranes, having a rake of twenty-five feet, and a capacity of three tons, so fixed that they can lift goods from the railway waggons to the platform, or to the hold of a vessel, or *vice versâ.* With screw steamers, of which the Company possess four, it is practicable by one operation to take a package from the waggons and deposit it in the hold of the vessel, but with paddle-wheel steamers, owing to their greater width, the hydraulic cranes are worked in connection with a winch which raises or lowers the goods between the hold and the deck.

The harbour and quays are illuminated at night by five powerful electric lights, one being fixed at each end of each warehouse, and the fifth at the south end of the harbour.

The mode of carrying on the working is as follows:—Waggons containing export traffic for shipment, having been brought by the train engines, and deposited close to the entrance of the export warehouse in reception sidings provided for the purpose, are drawn up by hydraulic capstans, and placed in exact positions opposite the berths, where are moored the vessels into which they are required to be unloaded. The goods are taken from the waggons, checked with the invoice, and lowered into the vessel, full particulars of the goods shipped by each boat being recorded in a "Transfer-book." The clerkage is carried on simultaneously with the actual handling of the goods, so that almost as soon as the hatchways are closed, and the gangways removed, the invoices are sent on board, and the vessel is ready to leave. Specially heavy articles, such as furniture vans or machinery, are loaded on the quay by means of 18-ton hydraulic cranes, or, if necessary, by a pair of shear legs, which will carry eighty tons.

With regard to import traffic, as soon as the vessel is berthed alongside the quay, the invoices are passed to a checker, who, for the guidance of the men on the platform, first makes out a "card," or list, of the urgent, or "perishable," traffic, showing the loads which have to be made up for different destinations, so that as the goods are landed from the boat, the ganger in charge of the men on the platform is enabled to direct the loading into waggons. By the time the urgent, or perishable, traffic has been dealt with, the checker has prepared another "loading-card" for the general cargo, and thus the discharging and loading-up of the goods is enabled to proceed without interruption, until the whole have been despatched.

Ireland being to so large an extent an agricultural country, an important feature in her exports to England is live stock, and for the transfer of this from the vessels to the waggons at Holyhead, the arrangements are very complete. There is accommodation for the unloading of the animals from the vessels at any height of the tide all along the front of the import warehouses, and this operation can be carried on at the same time as the unloading of parcels and the perishable goods traffic from the same boats, while, close at hand, is a covered pen set apart for the reception of lame and distressed animals who are unfit to walk to the cattle yard, such animals being loaded up and taken by an engine to the yard. The animals who are fit to walk are conducted by a convenient roadway to the yard, which contains covered accommodation for upwards of 180 cattle, 800 pigs, and fifteen horses, together with open pens capable of holding 230 head of stock. There are also pens erected alongside a siding, upon which twelve waggons can be placed in position for loading the animals up for forward transit. The sidings appropriated to the cattle traffic hold in all 140 waggons, and there are ample facilities for cleaning and disinfecting them after each journey, including twelve hydrants for the supply of water. During the year 1887, 76,700 cattle were transhipped at Holyhead to the various towns in England, in addition to 63,032 sheep, 27,110 lambs, 7,780 horses, and last, but not least, 157,411 pigs. The live stock shipped to Ireland from England is not considerable, but last year it included two lions and two elephants, although what these strange denizens of the far east were to do in the "distressful country," can only be a matter of conjecture.

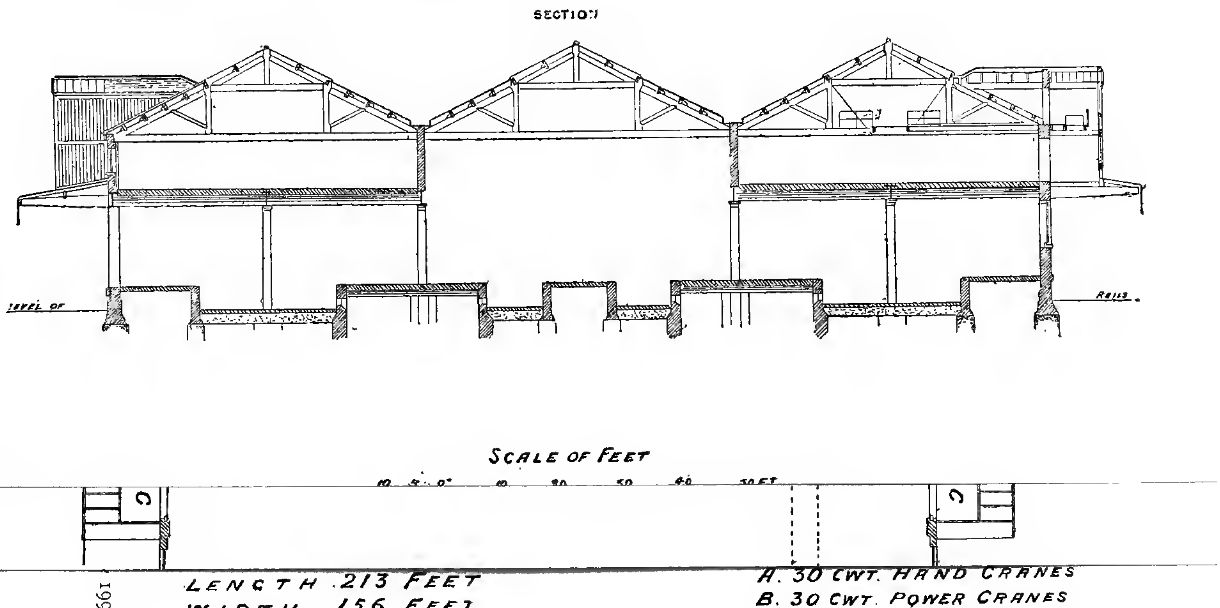
When import goods are loaded into waggons, a kind of inventory is made of them, which is termed a slip, and as soon as the load is completed, these slips are compared with the invoices, so as to discover and rectify any mistakes, as for instance, goods loaded in the wrong waggon. A transfer book is also kept, as in the case of the export traffic, and in this is recorded the date and number of the invoice, particulars of the traffic, the weight, the name of the vessel by which the goods are received, and the number and destination of the waggon in which they are loaded for forward transit.

As the waggons are loaded, they are turned over turntables on to adjoining lines of rails, where they are marshalled in proper order, labelled, and sheeted, and within a few minutes of the loading of the last waggon being completed, the train is ready to start. In discharging a vessel, as already mentioned, preference is always given to perishable and urgent goods, and these are despatched by express passenger trains within an hour after the boat is berthed, but within two hours and a half of the arrival of the vessel, a full train load, of sometimes upwards of thirty waggons, is despatched, while a second and a third train follow at intervals of not more than an hour, a striking proof of the excellence of the arrangements, and the energy and skill with which the operations are conducted.

There is a large fish traffic at Holyhead, and in dealing with this, speed is, of course, of the utmost importance, especially in hot weather. In order to accommodate the fish brought to the harbour by steamers and sailing vessels direct from the fishing grounds, the Company have constructed a fish jetty, 440 ft. long and 50 ft. wide, on the import side of the harbour, with two platforms and two lines of rails, each line being capable of holding twenty-five waggons. The loading from the vessels to the waggons is performed by means of three hydraulic cranes, each lifting 30 cwt., and having a sufficient rake to cover both platforms, so that two train loads of fish may be loaded simultaneously. To save time, the empty waggons are placed in proper station order, so that there shall be no delay in marshalling them, and the labels and way-bills being prepared while the loading is proceeding, the train can start on its journey as soon as the last load is completed.

At all the Company's large goods stations, ample provision is made for the prevention or extinction of fire, fire brigades composed of members of the staff being organised, drilled, and frequently called together by signal for exercise, and these precautions are not omitted in the case of Holyhead. The fire appliances here are of a very complete description, and water is supplied from no less than sixty-three powerful hydrants.

L & N.W.R. NEW GOODS WAREHOUSE AT CHESTER



The total traffic handled at Holyhead during the year 1887, in addition to live stock, was about 250,000 tons, including coal; of this total about 117,000 tons was cross-channel traffic with Ireland.

It has always been a question involving some amount of controversy, as to what is the best and most convenient manner of laying out the accommodation in a large goods warehouse, so as to enable the business to be carried on in the most expeditious and economical manner. Many different arrangements have been tried, and, of course, in building a warehouse at any particular station, there may always be special circumstances to be taken into consideration, such as the nature of the traffic, and the available space; but our illustrations (Figs. 29, 30 and 31) shew the ground plan, first-floor plan, and section, of a large goods warehouse of the first class, built upon the most modern principles, and laid out in the manner which is believed to be the best adapted to the needs of an important goods station (Chester), where three different classes of traffic have to be dealt with, that is to say (1), local traffic, or traffic which commences or ends its journey at the station; (2), transfer traffic, or traffic loaded to the station, for the purpose of being transhipped into other waggons, and forwarded to destination; and (3), warehouse traffic, or goods which are required to be stored, awaiting orders for forwarding or delivery. It will be perceived that this is what is termed a "dead-end" warehouse, or, in other words, the waggons come in and go out the same way, and cannot be taken *through* the warehouse, and out at the other end. There are five platforms, or stages, and six lines of rails, so that every platform, as will be seen, has a line of rails alongside it, and three of them have a line on each side. There is also a stage running transversely along one end of the building, to which access is given by a roadway for carts. To facilitate the handling of the heavy goods, there are in all twenty-four cranes, each carrying thirty cwt., four of which are power cranes, and the rest are worked by hand. The upper floor is devoted to storage purposes, and to enable grain to be conveniently delivered from this storey, slides are provided, down which the sacks can be passed to the ground floor; there are also a number of shoots for transferring loose grain from sack to sack. Grain in sacks can be hoisted direct from the waggons or carts below to the upper storey by means of cranes, but if required to be stored in bulk, it is lifted by crane to a gangway, or gallery, erected *over* the upper storey, and supported on the principals of the building, and then is shot out of the sacks into bins below, through shoots provided for the purpose.

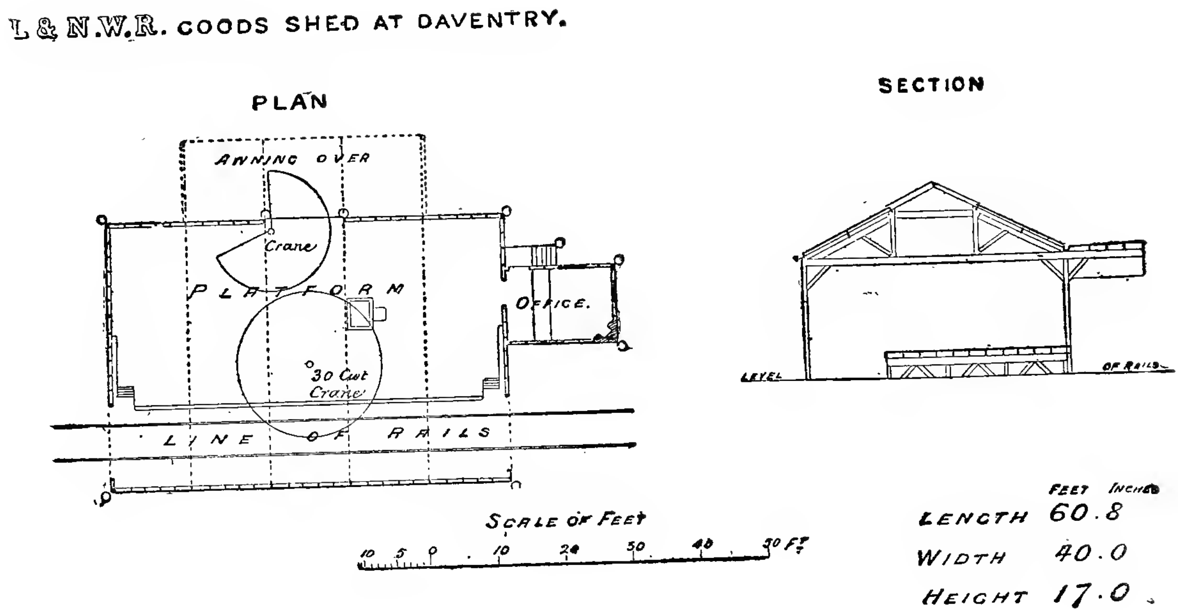
Under the stages of the warehouse are capacious cellars for the storage of ale, bacon, and such commodities, which can be lifted or lowered direct between the cellars and the carts, or railway waggons, by means of suitable cranes.

Waggons containing goods arriving by train for delivery in the town, are placed on the outer line of rails, next to one or the other of the side stages, nearest the walls, and as carts can approach either of these from the side of the warehouse, where they stand sheltered by a projecting awning, the goods can be transferred by the cranes direct from waggon to cart, or light goods can be handed across the platform. Other town goods can be unloaded in the second line of rails on either side, and trucked to the platform at the end of the warehouse, where carts can approach them. Outward goods, collected in the town for forward transit, are brought in by carts, unloaded on the transverse stage, and trucked thence to the various stages alongside which the waggons have been placed for their reception. The narrow centre platform, having a line of rails on each side, and cranes suitably arranged, is appropriated to transfer traffic which can thus be easily removed from one waggon and placed in another.

A warehouse of this description and dimensions will accommodate upwards of forty waggons at one time, and in this particular warehouse about eighty are loaded daily, and ninety are discharged. Warehouses designed upon this plan are in use at Liverpool (Edge Hill), Bolton, Blackburn, Leicester, Derby, Chester, and other stations.

Fig. 32 is an illustration of a small wooden goods shed, suitable for a roadside station, where the traffic to be dealt with is purely local, and not of an extensive character. The arrangement, in this case, is so simple and obvious, as to speak for itself and to require no detailed description.

In goods warehouses where a small amount of machinery requires to be actuated, and the business to be conducted is not sufficiently extensive to justify the application of steam or hydraulic power, a gas engine is found to afford very satisfactory results, both as regards economy and convenience, as a means of actuating the cranes. For a machine of this kind no special attendant is required, as one of the ordinary warehouse porters can start and stop the engine when necessary, and clean and oil it in his spare time. The peculiar advantage of the gas engine is that it can be



L & N.W.R. GOODS SHED AT DAVENTRY.
PLAN
ANNING OVER
Crane
PLATFORM
OFFICE.
30 Cwt Crane
LINE OF RAILS
SCALE OF FEET
10 5 0 10 20 30 40 50 FT
SECTION
LEVEL OF RAILS
FEET INCHES
LENGTH 60.8
WIDTH 40.0
HEIGHT 17.0

FIG. 32.

started and stopped at a moment's notice, and there is accordingly no waste of fuel whatever, besides which the first cost of the machinery is very moderate compared with that of hydraulic power on a small scale, and the average cost of gas for an eight h.p. gas engine is not more than from threepence to sixpence per hour, according to the price of gas in the locality, and the work required of the engine

The London and North-Western Company have at the present time thirty warehouses in which the machinery is actuated by gas engines, varying from one and a half to eight h.p., according to the size of the building, and the number of cranes and lifts required. A good example of this class of machinery is found at the Northampton warehouse, erected by the North-Western Company, in 1881. In this warehouse there are two cranes of thirty cwt. capacity, and two 10-cwt. friction jiggers, worked by a gas engine of eight h.p., the first cost of the installation having been £950. The cost of gas consumed (about 108,300 cubic feet) averages £10 10s. per annum, in addition to about £3 10s. for maintenance and repairs, and £3 5s. for oil and waste, etc.

CHAPTER XIII.

RATES AND FARES—DIVISION OF TRAFFIC—THE RAILWAY CLEARING-HOUSE.

IT is not the intention of the present writer to enter very deeply into the thorny and much debated question of railway rates, and the many controversial points arising out of them. The late Mr. Grierson, General Manager of the Great Western Railway Company, in the work published shortly before his lamented decease, and entitled, "Railway Rates, English and Foreign," has so completely exhausted this subject from almost every point of view, that, from the stand-point of the railway companies at least, there remains very little to be said. In a work of this character, it will be sufficient to give merely a brief account of the manner in which rates and fares are made, and the way in which the different railway companies share the receipts amongst themselves, where those receipts are derived from "through" traffic, *i.e.*, traffic which has to be carried over more than one railway before its transit is completed.

The rates and fares to be charged upon a railway are, in a sense, regulated by Act of Parliament; that is to say, that, until recently, the Act which authorised the making of the railway fixed the *maximum* tolls, which were not to be exceeded for any traffic using the line.

In practice, however, the maximum tolls were rarely charged, and a great deal was left in the discretion of the railway companies—moreover, it is impossible for an Act of Parliament to fix the precise charge to be made for each particular commodity which may be conveyed over a railway, and, as a matter of fact, the articles specified in the Acts were comparatively few in number, the remainder being summed up in the comprehensive phrase, "other articles, matters, and things." In fixing its rates, therefore, a railway company had to classify these "articles, matters, and things," as nearly as might be with relation to the commodities which were actually specified in the Act. This necessity was met by the companies meeting in conference at the Railway Clearing-house, and drawing up a comprehensive list of the articles usually carried on railways, classifying them under eight different heads, according to their weight, bulk, value, and destructibility, in what is called the "Clearing-house Classification;" for instance: minerals, sand, and such matters, would be in the lowest class, while fresh fruit and fish, furniture, china, and other valuable or fragile articles would be in the highest. Each company then fixed its rates between each pair of stations for each class of goods in the classification, having due regard to its *maximum* powers; but in addition to these "class rates," there were always a number of special rates for particular descriptions of goods.

But the old order of things has been totally changed since the passing of an Act in the last session of Parliament, entitled "The Railway and Canal Traffic Act of 1888," the provisions of which will be more particularly described in the succeeding chapter. The general effect of it, however, has been to place upon the railway companies the obligation of submitting an entirely new classification and schedule of maximum charges, which, after running the gauntlet of all objectors, and securing the approval of the Board of Trade, will be embodied in an Act, and receive the sanction of Parliament.

The rates are governed by the nature and extent of the traffic, the pressure of competition, either by water, by a rival railway route, or by other land carriage; but, above all, the companies have regard to the commercial value of the commodity, and the rate it will bear, so as to admit of its being produced and sold in a competing market with a fair margin of profit. The companies each do their best to meet the circumstances of the trade, to develop the resources of their own particular district, and to encourage the competition of markets, primarily, no doubt, in their own interest, but nevertheless greatly to the advantage of the community.

The fixing of passenger fares is a comparatively simple process. Between local stations on the North Western Railway the fares are made up, roughly speaking, on the basis of charging twopence per mile travelled for first-class passengers, three half-pence per mile for second-class, and one penny for third-class, the amount of the passenger duty being added to the first and second-class fares; but where there are competing routes, or where, in suburban districts, the opposition of omnibuses or tramways has to be encountered, the fares are often considerably reduced. Railway companies are sometimes very unfairly assailed when they reduce their rates or fares in order to meet competition, and it is somewhat hastily assumed that, if they were able to reduce their charges on compulsion, it was incumbent on them to have done so before. Thus, it is not uncommon to hear the remark, "The —— Company have had to reduce their fares at last, thanks to the opening of the —— line." This is, however, unjust. So long as competition does not exist, the companies are only discharging their duty to their shareholders in obtaining what Parliament has sanctioned as a fair rate of remuneration for the services they perform, but when there is a rival in the field, they are justified in concluding that "half a loaf is better than no bread at all"; although it by no means follows that their previous charges were unfair or excessive.

In days gone by, it cannot be denied that railway companies incurred great losses and sacrificed a considerable portion of their revenue by extreme competition amongst themselves, but in this matter, as in many others, they have gained wisdom by experience, and "profited by the uses of adversity." A certain amount of healthy competition will always exist; but the companies now mitigate its severity by agreeing amongst themselves what the rates between competing points shall be by all routes. The competitive rates between most places in Great Britain are, in the main, governed by two Conferences, "The English and Scotch Traffic Rates Conference," and the "Normanton Conference." The English and Scotch Conference is composed of representatives (who are usually the Chief Goods Managers) of all the companies, both English and Scotch, who are interested in the carriage of goods between places in England and places in Scotland by the various routes. These representatives meet once a month, and deal with all questions arising in connection with the making of new rates or the alteration of existing rates for competitive places between which more than one company can carry. The Normanton Conference, which was originally established to control the rates for a certain district of which Normanton, where its meetings were formerly held, was a convenient centre, has gradually so much extended its scope that it is now composed of representatives of nearly every company of any importance in England, and governs almost the whole of the competitive rates which are not dealt with by the English and Scotch Conference. The cross-channel rates between England and Ireland are controlled by an "English and Irish Traffic Rates Conference," and, besides these three, there are some minor Conferences which have been established in connection with the traffic of particular districts, but have not the importance of those which have been already alluded to.

In addition to the system of agreeing the rates between competing points, there is another plan which railway companies sometimes adopt, in order to avoid the losses arising from competition, which is known as "Percentage Division of Traffic," and which is carried out in the following manner. Supposing that there is a certain traffic to be conveyed between two towns or districts, and that there are two or more railway companies, each having a route of its own by which it is enabled to compete for the traffic. An agreement is come to that the receipts derived from the whole of the traffic, carried by all routes, shall be thrown into a common fund, and that each company shall be entitled to a certain percentage of the whole—say, for example, 50 per cent. to the company having the best route, 30 per cent. to the second, and 20 per cent. to the third. The percentages are usually adjusted on the basis of past actual carryings, but in settling the terms of the agreement due weight is accorded to any prospective advantages which may entitle one company to claim a larger proportion than it has carried in the past. An agreed allowance for working expenses is made to any company carrying more than the percentage allotted to its route, but, as this allowance is fixed with due regard to the actual cost of the service, it will be perceived that there is no very great inducement for any company to carry more than its share.

Let it not be hastily concluded that an agreement of this kind is opposed to the interest of the general public, for it may safely be asserted that in the long run it is a mistake to imagine that the public are the gainers by an extreme course of competition between two railway companies. If the contest is waged to the bitter end, the public may enjoy low rates for a time, but the result must be the "survival of the fittest"—or, rather, the strongest—and the latter, becoming masters of the situation, will naturally seek to recoup themselves for the severe losses they have sustained during the progress of the struggle. Meanwhile, neither of the competitors will have been in a position to perform the services they have undertaken in as efficient a manner as would have been the case if they had been working with a fair margin of profit. The only competition from which the public can reap a real and lasting advantage is that of two companies carrying at fair and remunerative rates, and each seeking to attract business to its own railway by performing the service to the public in the most efficient, safe, and expeditious manner.

It must be admitted that railway companies set a good example to the community at large in the method they adopt of settling disputed claims and other matters of difference between themselves instead of having recourse to expensive litigation. By the terms of an Act passed in the year 1859, and entitled the "Railway Companies' Arbitration Act," it was provided that any two or more companies might, by writing under their Common Seal, agree to refer to arbitration any differences or disputes in which they were mutually concerned, and which they might legally settle by agreement between themselves. This Act is incorporated in all modern Acts of Parliament and in most agreements entered into by railway companies, and the effect is to reduce litigation between them to a minimum, with a consequent great saving in expense. Under the Act, the arbitrators have power to call for the production of books and documents, to administer oaths, and hear evidence, and their decisions are final and binding upon all concerned, and may be legally enforced in any of the Superior Courts of Law. Two companies may agree to appoint a single arbitrator, or each company concerned may appoint one, in which case the arbitrators appoint an umpire to decide between them in case of difference. In the event of either company failing to appoint an arbitrator after having agreed under seal to do so, or of the arbitrators failing to appoint an umpire, the Board of Trade may be called upon by either of the other companies concerned to name an arbitrator or an umpire, as the case may be.

A very complete machinery exists for the settlement of cases of disputed liability for claims arising on through traffic in which two or more companies are concerned. A tribunal has been constituted which is termed the

"Claims Arbitration Committee," and which holds its meetings at the Railway Clearing-house in London once each month. It consists of twelve members chosen by election from their own body by the Goods Managers of the companies who are parties to the Railway Clearing-house, the members holding office for three years, and one-third of them retiring annually and not being eligible for re-election until after the lapse of a year from their retirement. When two or more companies fail to agree as to the liability for a claim arising upon traffic in which they are jointly interested, either party to the dispute may, by giving due notice, appeal to the decision of the Claims Arbitration Committee. Statements of the facts are drawn up and submitted on either side; and, after examining these, the Committee hears the evidence and arguments of the parties concerned, and gives its decision, which is held to be final.

For claims arising upon through passenger traffic there is a similar committee, having the same functions and constituted in the same manner, but which, in this case, consists of twelve Passenger Superintendents, elected by the members of the Superintendents' Conference. There can be no question as to the great advantages of a system of this kind; for not only are railway companies saved a vast expense which would otherwise be incurred in litigation, but the cases are adjudicated upon by able and experienced railway men, who are perfectly conversant with the facts, and incomparably more competent to arrive at a satisfactory decision than any other tribunal which could be selected. It should be mentioned that in order to secure the complete impartiality of the Committee, no member is permitted to take part (except as an advocate) in the proceedings upon any case in which the company he represents is in any way interested.

In cases where traffic, in being conveyed from its starting point to its destination, has to be carried over the railways of two or more companies, the receipts are divided between the companies concerned in proportion to the mileage travelled over each railway. In the case of merchandise traffic, before this division is made, a certain fixed sum is allowed (according to the class of traffic) to the forwarding and receiving companies respectively, for terminal expenses; that is to say, for the use of the stations, and for the services of loading and unloading and clerkship. A simple illustration will perhaps best serve to show the working of this arrangement.

We will suppose that a ton of goods has to be forwarded a distance of 100 miles, and in completing its journey has to travel 60 miles over one railway (A) and 40 miles over another (B). We will assume that the freight amounts to 23s. and that the terminal allowance at each end is 4s.:

Company A will receive—

$$\frac{60}{100} \text{ of } 15\text{s.} = 9\text{s.} + 4\text{s.} = 13\text{s.}$$

Company B will receive—

$$\frac{40}{100} \text{ of } 15\text{s.} = 6\text{s.} + 4\text{s.} = 10\text{s.}$$

Total ... 23s.

The question of division of traffic brings us to the consideration of one of the most important features of the railway system, which is known as the Railway Clearing-house. In the early days, when railways began to multiply and to run in connection one with another, it was necessary for a passenger who had to travel over two railways before his journey was completed, to change carriages on the termination of the first one and to take a fresh ticket; and similarly every consignment of merchandise had to be transhipped from one company's waggon to that of another at the point of junction, and to be re-invoiced. As the business increased, this was soon found to be a perfectly intolerable system, and a demand arose from the public that they should be enabled to travel between any points by paying the fare for the whole journey at the place of departure, and that in the same way merchandise and live stock should be forwarded throughout without sustaining the delay and possible damage involved in frequent transhipments. The difficulty to be overcome in giving effect to this demand was twofold; for not only would one company be receiving money part of which was due to another company, but each would be obtaining a service from the carriages and waggons of the other for which, clearly, some payment must be made. For a time the companies attempted to meet the case by a system of keeping accounts and exchanging returns of the receipts of each from through traffic; but this plan was open to many objections. Different companies had different modes of keeping their accounts, and no one had any authority to impose uniformity; so that there were mutual difficulties in agreeing the figures, and the consequent disputes engendered ill-feeling, recriminations, and charges of unfair practice. At length, in the year 1842, it occurred to Mr. Morison, who was at that time an audit clerk of the London and Birmingham Railway, that the true remedy for the unfortunate state of things which prevailed was to establish a central office, founded somewhat upon the lines of the Bankers' Clearing-house (which had then been established more than half a century), and which should receive the returns of through traffic from all the companies, impartially make the apportionments, and declare the balances due to each. The scheme thus outlined met with the warm approval and support of Mr. Glyn, who was at that time the chairman of the London and Birmingham Railway, and, after sharing the fate of every innovation or reform in encountering a great deal of opposition from various sources, it was finally brought into operation. Like most great institutions, the Railway Clearing-house had a very humble commencement, for it began its operations with a staff of only four clerks, and dealt with the traffic of only four railways, controlling an aggregate mileage of 418 miles; but its growth has only been paralleled by the growth of the railway system itself, and the magnitude of its operations may be judged by the fact that it employs at the present time a staff of not much less than 2,000 persons, and deals with the traffic of all the railway companies in Great Britain, having, in the aggregate, nearly 17,000 miles of railway. If we add that during the year 1887 the number of traffic settlements made was 9,000,000, and the value of the receipts dealt with was £16,500,000, we shall have said enough to give a fair idea of the extent of the business carried on in the vast building in Seymour Street, Euston Square, where the Railway Clearing-house has found a home.

Since the year 1850 the proceedings of the Railway Clearing-house have been regulated by Act of Parliament

(13 and 14 Vic., cap. 33), and its authorised functions are thus defined: "To settle and adjust the receipts arising from railway traffic within, or partly within, the United Kingdom, and passing over more than one railway within the United Kingdom, booked or invoiced at throughout rates or fares." The management is conducted by a Committee of Delegates appointed by the boards of the several railway companies, parties to the system, each company, however great or small, having the power to appoint one delegate, and the expenses being borne by the companies in the ratio of the amount of business done on their behalf. Any railway company not a party to the clearing system may apply under seal for admission, and if the Committee of Delegates assent to the application, the company is at once received on an equal footing with all the other companies already parties to the system. Any company may withdraw at will by giving one month's notice under seal, or a company may be expelled by the vote of two-thirds of the delegates present at a meeting specially convened for the purpose. The Committee meets four times a year, or oftener if needful, and its chairman is elected annually, but is eligible for re-election indefinitely.

The accounts of the clearing system, and the balances due to and from the several companies, are settled and adjusted by the secretary, who also determines the amount to be from time to time contributed to the funds of the Clearing-house by each company. In case of any difference arising with respect to the accounts, the decision of the Committee that a certain balance is due and payable by a particular company is final and conclusive, and such balance is recoverable in a court of law, upon simple proof that the committee have declared the amount to be payable.

In earlier days, the operations of the Clearing-house were limited to dealing with passenger and parcel traffic, and the mileage and demurrage charges for the use or detention of carriages, waggons and sheets, when travelling upon railways other than those belonging to the owners of the stock; but since the year 1847 the system has been extended to merchandise and live stock traffic, including a considerable proportion of the through coal traffic. The general principle upon which the receipts arising from through traffic are apportioned between railway companies has already been described, but two or more companies frequently enter into agreements for special modes of division of certain traffic, and the Clearing-house gives effect to these on receiving "joint instructions," mutually agreed between the companies concerned, the system being sufficiently elastic to meet every kind of agreement that can be devised for the apportionment of traffic receipts. In any case in which one company claims a larger share of the receipts from a particular traffic than its partners are prepared to concede, the Clearing-house reserves, in making the apportionment, a sufficient amount to meet the claim, until the difficulty can be adjusted by agreement, arbitration or otherwise, and amounts thus reserved are said to be "in suspense."

Having described the results achieved by this admirable organisation, it may be worth while to glance briefly at the machinery by which those results are attained.

In the first place, all through tickets are forwarded to the Clearing-house; for instance, if a passenger books to-day from London to Aberdeen, on the completion of his journey, his ticket is sent to the Clearing-house, and each of the companies over whose railway he has travelled is credited with its due mileage proportion of the fare he has paid. The same course is adopted with regard to the invoices of merchandise traffic; but, in addition to this, every station makes a return to the Clearing-house daily of passengers and parcels booked through, and of carriages and waggons, either loaded or empty, received and despatched. Then, scattered all over the country, at every junction of two railways, the Clearing-house have number-takers stationed, who record the number and description of every vehicle that passes a junction going from one line to another, and these men forward returns to the head office in Seymour Street. All these returns are examined, analysed, and checked, one with another, and thus, with enormous labour, but with the most marvellous accuracy, the accounts are made up and the balances declared. The advantages of such an institution as this, which has had such great results in facilitating intercourse and the trade of the country, can hardly be over-estimated, for it is only by means of this system that the produce of remote districts has been brought to the door of the consumer; while, as for Ireland, if the facilities thus afforded for her cattle, poultry, butter and eggs to command the English markets had not existed, it is certain that the social condition of her people must have been much worse than it is.

The Clearing-house, however, discharges other functions besides the division of traffic receipts. It affords a convenient neutral ground where the various companies, whatever their conflicting interests or differences of policy, can meet on friendly terms, can agree upon measures of concerted action, and afford one another the benefit of their mutual experience in devising measures for the common good. Three important conferences are held at the Clearing-house every three months, one attended by the general managers of the different companies, another by the goods managers, and a third by the passenger superintendents, all these dealing with the subjects specially germane to their respective departments. Thus the Goods Managers' Conference deals with such questions as the construction of private waggons, the charges for the use of waggons, the classification of goods traffic, terminal allowances, etc.; the Superintendents' Conference deals with the speed and signalling of trains, rules and regulations for working the railways, the block telegraph system, excursion trains and subjects of like nature; the General Managers' Conference reviews the recommendations of the Goods Managers and Superintendents, and, in its turn, frames proposals to be submitted to the Committee of Delegates for adoption by the companies.

Besides these three, there are a host of other committees and rates conferences for various purposes which hold their meetings at the Clearing-house, and the total number of such meetings held in the course of a year is upwards of 250.

Since the year 1847, the Railway Clearing-house, as a central establishment well adapted for the purpose, has been employed to facilitate the recovery of lost luggage, a duty which it discharges in the following manner. A description of every article lost or found is forwarded daily to the Clearing-house, who, in turn, furnish the information to the different stations, and anything found on hand at a station which answers to the description of an article lost is sent up to the Clearing-house for identification. During the year 1887 nearly half a million of articles were reported to the Clearing-house as being lost or found, and in the majority of cases, thanks to the machinery employed, the owners were traced and their property restored to them.

CHAPTER XIV.

ON THE RELATION OF THE STATE TO RAILWAYS IN ENGLAND, AND THE QUESTION OF STATE PURCHASE OF RAILWAYS.

AS is well known, the relations of the State to railways differ in various countries to a very wide extent. For instance, in Belgium, practically the whole of the railways have been purchased by the State, and are worked by a department of the Government for the benefit of the public, very much as the Post Office is in England.

In Prussia, Bavaria, Wurtemburg, and most of the other German States, nearly the whole of the railways have been acquired by the Government and are worked as a Department of State; while in Austria, with the exception of one line, which is a State railway, the whole of the railways have been made and are worked by private companies, the Government merely exercising a certain power of control over the fixing of the rates and charges.

In France, some of the railways have been constructed and are worked by the State, and others have been made by private companies, but on a system of territorial concessions, by which these companies are secured against competition, and the Government, in consideration of this fact, exercise a complete control over the fixing of the rates. In India, the railways have been constructed under various conditions, some of them by joint-stock companies, as in England, but guaranteed by the State, while others have been built absolutely by the Government. In the United Kingdom, all the railways have been constructed by joint-stock enterprise, under the sanction of Parliament, without any subsidy or guarantee whatever; but Parliament, in granting the powers to buy land and make a railway, fixes the *maximum* tolls to be charged, and the Government, under various Acts of Parliament which have been passed from time to time, retains certain powers of inspection and control which will be more particularly detailed hereafter.

It may be said that, *prima facie*, anyone has the right to construct a railway on their own land and for their own use, and, similarly, a joint-stock company can be formed for any purpose by complying with certain formalities and by the process of registration; but when a number of individuals desire to form themselves into a company for the purpose of making a railway for public traffic, they require to obtain from Parliament compulsory powers for the purchase of land, whether the owners are willing to sell or not, to cross highways, divert roads and footpaths, to bridge rivers, and to make legal bye-laws, the breach of which shall be penal. Therefore, the first thing to be done by any group of promoters who desire to construct a new railway is to deposit a Bill, together with plans showing the course of the line and the limits of deviation. The Bill, if opposed, is referred to a Select Committee of the House of Commons, and subsequently to a like Committee of the House of Lords, and both these Committees sit and hear all the evidence that can be adduced, both on behalf of, and in opposition to, the Bill, as well as the arguments of the counsel employed on each side. The opposition usually proceeds from private landowners, from Corporations and Town Councils, and from other Railway Companies who foresee competition from the new comers; but where a good case can be made out, and the Committee can be fairly satisfied that the construction of the new railway is required and will be for the advantage of the public, the powers sought for are usually granted, and the opposition is satisfied as far as may be necessary by the insertion of accommodation or protective clauses in the Bill.

The Bill having been sanctioned by Parliament, the company next proceed to purchase the land, and here they find the advantage of the powers they have obtained; for if they find a landowner unreasonable and exorbitant in his demands, they can serve "notice to treat," and claim to have the merits of the case investigated either by a sheriff's jury or by arbitrators, who will hear evidence and decide what is a fair price to be paid, which price the landowner is bound to accept. The case was widely different with the promoters of the early railways, who had to submit to the most excessive demands on the part of the landowners as the price of their consent to sell their land for the purposes of the railway, and we are told, for instance, that the land for the London and Birmingham Railway, which was liberally estimated to cost £250,000, actually cost three times that amount, or about £6,300 per mile, the most extravagant sums having to be paid for compensation, for consequential, damages for fancy prospects, and other unreasonable demands, in order to buy off the opposition of the landowners. Claims such as these are not heard of in these days, or if they were, they would at once be scouted by any jury or arbitrator before whom they were brought.

The growth of the traffic on the principal railways has brought about the necessity of widening or laying down additional lines of rails upon the principal trunk railways, and as this usually involves the purchase of additional land, and more or less interference with public roads and bridges, the operation has to be sanctioned by Parliament very much in the same way as if an absolutely new line of railway were contemplated, although there is not, as a rule, so much serious opposition to be encountered.

Another point of contact between the railway and the State is the power of control, within certain limits, possessed by the Board of Trade. Before any new railway or branch line can be made use of, it must be examined by the Inspecting Officers of the Board, and the permanent way, bridges, stations, and signals must be certified by them as being satisfactory and in accordance with a schedule of requirements laid down by the Board, and to which all railway companies are bound to conform. The same applies to any new line, or siding, or any interference, however slight, with the lines upon which passenger trains run. All accidents involving the least injury to life or limb, whether of passengers or the servants of the company have to be reported to the Board of Trade, who, in every case where they consider it necessary, appoint one of their Inspecting Officers to view the *locus in quo*, and hold an enquiry upon the spot into the circumstances of the mishap, hearing evidence, and reporting to the Board of Trade. A summary of these reports is submitted to Parliament annually.

The Board of Trade have also power to compel the companies to make use of a proper system of communication between passengers, guards, and drivers, to impose regulations as to the use of level crossings, to order bridges or subways to be constructed in lieu of level crossings, to insist upon the running of workmen's trains where they consider it necessary, and to call for various statistical returns from the railway companies.

In 1873, an Act was passed entitled the "Railway and Canal Traffic Act," which contained provisions of great importance as affecting the railways in this country. Divested of various minor enactments and of all unnecessary verbiage, the essential principles of this Act were as follows :—

(1) A new tribunal was constituted consisting of three "Railway Commissioners," one of whom was to be of experience in the law, and another of experience in railway business, who were to decide all questions of difference between any two railway companies, or between a railway company and a canal company or between any individual and a railway or canal company, upon the application of either party to the difference.

(2) It was ordained that where two railways formed part of a throughout route between two given points, one of the said companies might call upon the other to afford facilities for the conveyance of through traffic over the lines of the two companies, by giving written notice of the through rate to be charged and the route to be travelled. If the company receiving the notice objected to the rate or the route, the matter was to be referred to the Railway Commissioners for decision.

During the fifteen years that this Act has been in force, the Railway Commissioners have had a considerable number of cases submitted to their judgment, and although their decisions have not at all times escaped severe criticism, it cannot be denied that they have dealt fairly and equitably, on the whole, with the questions which have been brought before them.

During the last few years a demand has arisen from certain quarters for fresh legislation in a spirit apparently hostile to railway companies, although mistakenly supposed to be in the interest of the general public. The promoters of this agitation have assumed that the rates and charges of the companies were too high, and that the commerce of the country would benefit if the State were empowered to fix the rates, instead of leaving the companies to do so within the limits of their toll powers. The companies have strenuously opposed this demand, on the perfectly logical ground that Parliament, having sanctioned the existing railways, with power to take certain tolls for their use, upon the faith of which the capital for their construction had been subscribed, had no just claim to deprive the shareholders of a portion of their profits, unless it was prepared to compensate them for their loss. It is also argued, and is easily susceptible of proof, that the railway companies, so far from having unfairly taxed the trade of the country, as is asserted by their assailants, have been its best friends, and have done everything in their power to foster and encourage it; treating the public fairly and liberally, and keeping well within their powers as regards tolls. They would, indeed, have been suicidal in acting otherwise, for their course is shaped by men of business, who are well aware that the prosperity of trade means the prosperity of the railway companies, and that, in short, the welfare of each is dependent upon the other.

The public, however, it is to be feared, are far from realising how much the companies have done for them, or how the conditions of railway transit, both for passengers and merchandise, have been revolutionised in their favour in these modern times, without the companies reaping any additional remuneration, the maximum tolls being now precisely what they were when the railways were first authorised, while in every other respect the scene has entirely changed. The stations, which were once of the most primitive description, consisting of little more than a platform and an office, have been replaced by costly and elaborate structures, replete with every kind of accommodation, and erected at a large expense; the trains are luxuriously fitted up with every modern appliance for comfort and convenience, and run at a rate of speed never dreamt of in the earlier days; the merchandise is carried in express goods trains from one end of the country to the other within the twenty-four hours; vast sums have been spent in providing warehouses and depôts, machinery and appliances, where, in the old days, the companies simply took their tolls for the use of the rails and left others to find the accommodation; and yet, for all these advantages, they exact no increased payment. On the contrary, during the last few years great concessions have been made to the traders in the matter of rates; and wherever it has been shown that a particular industry could be developed or created by the quotation of low rates, or the granting of any other facilities, the companies have always been willing to meet the case in a liberal spirit, recognising the fact that in so doing they were consulting their own best interests as well as those of the public.

There is no doubt that the agitation against the railway companies has arisen in consequence of the depressed state of trade which has existed during the last few years, not only in this country, but all over the world, many of the largest undertakings in the coal and iron industries having been carried on in fact with little or no margin of profit to those interested in them; but, whatever the cause of the agitation, it has had sufficient force to induce two successive Administrations to attempt legislation in order to satisfy it.

In 1886 Mr. Mundella, the then President of the Board of Trade, introduced a "Railway and Canal Traffic Bill," which met with vigorous opposition on the part of the railway interest, but Mr. Gladstone's Government fell before any decision was arrived at with regard to it. In the last session of Parliament (1888), however, a bill was introduced by Lord Salisbury's Government, and with some modifications in Committee became law, under the title of the "Railway and Canal Traffic Act, 1888," containing, *inter alia*, the following provisions:—

(1) The Railway Commissioners' powers, as defined by the Act of 1873, are renewed, and their body is re-constituted so as to consist of two appointed members (one of whom is to be of experience in railway business), and three ex-officio commissioners, one for England and Wales, one for Scotland, and one for Ireland, these latter being judges of a superior court, each of whom will preside in cases only which are heard in that part of the United Kingdom for which he is nominated.

(2) Town councils, county authorities, urban and rural sanitary authorities, harbour boards, chambers

of commerce, trade associations, and, in short, almost every constituted body may become the plaintiff to the Railway Commissioners in any matter in which that tribunal has jurisdiction.

(3) The new Commission is invested with jurisdiction over disputes as to the legality of tolls, rates, and charges, and may enforce payment of them, may order traffic facilities to be granted, notwithstanding agreements between companies to the contrary, unless the agreements are confirmed by Act of Parliament, by the Board of Trade, or by the Commissioners themselves, and may award damages to aggrieved parties.

(4) Every railway company within six months of the passing of the Act, is to submit to the Board of Trade a revised classification of merchandise traffic, and a revised schedule of maximum rates and charges applicable thereto proposed to be put in operation, and is to state the nature and amount of all terminals proposed to be authorised in respect of each class of traffic. The Board of Trade are to consider the classification and schedule of charges, to hear any objections made by any parties whom they consider entitled to be heard, and on coming to an agreement with the company as to what the classification and schedule of charges are to be, are to embody them in a Provisional Order, submit them to Parliament, and bring in a Bill for an Act to confirm the order. If the Board of Trade cannot agree with the railway company, they (the Board) are to determine for themselves what they consider fair and reasonable, and report to Parliament, calling attention to the points of difference; certain machinery is then provided, by means of which

Parliament will, in the end, decide between the Board of Trade and the railway company.

(5) Where complaint is made that a railway company unduly favours one trader or body of traders, or the traders of a particular district, by charging them less than they charge other traders or districts for similar services performed, the burden of proving that the difference in treatment does not amount to undue preference is cast upon the railway company. In deciding cases of alleged undue preference, however. the Commissioners may consider whether the lower charge or difference in treatment is necessary for the purpose of securing in the interests of the public the traffic in respect of which it is made; no difference, however, is to be sanctioned in the tolls, rates or charges for home and foreign merchandise in respect of similar services.

(6) Any person receiving or sending goods by any railway who believes he is being charged an unfair or excessive rate may complain to the Board of Trade, who, if they think there are reasonable grounds for the complaint, may appoint a competent person to communicate with both parties and endeavour to bring them to an arrangement.

Such are the leading provisions of an Act which the railway companies, it need hardly be said, opposed so long as there was any utility in opposition; but seeing that the majority was against them, they have recognised the wisdom of bowing to the inevitable, and loyally accepting this Act as a compromise of propositions of an even more extreme nature. They feel, however, that the railway interests have been hardly dealt with, and, in particular, that the introduction of the clauses providing for a revision (which may imply a reduction) of the tolls fixed by the Acts of Parliament authorising the construction of the railways, constitutes an extreme measure not warranted by the circumstances or by any failure in their duty to the public on the part of the railway companies. On the contrary, the Railway Rates Committee of 1882, after going very fully into the subject and hearing an immense mass of evidence, mostly offered in a spirit hostile to the railway companies, have recorded their conviction in the following words, which will be found in their report :—

"Your Committee, in conclusion, report that on the whole of the evidence they acquit the railway companies of any grave dereliction of their duty to the public. . . . . . Your Committee find that the rates for merchandise on the railways of the United Kingdom are, in the main, considerably below the *maxima* authorised by Parliament."

But there are not wanting those who are advocates of measures of a much more sweeping nature even than those involved in the legislation of the last session, and who go so far as to propose nothing less than that the Government should become the purchasers of all the railways in the United Kingdom, and work them as a department of State for the benefit of the public, the assumption being that by the concentration of the management, the absence of competition, and the appropriation of the profits reaped by the existing railway companies to the reduction of the present rates and charges, great benefits must accrue to the public at large. This proposal is one which has been more or less the theme of discussion from a very early period, and indeed it is a fact not perhaps generally known that an Act was passed as long ago as 1844 empowering the Government to acquire the whole of the railways on certain terms, and that the Act in question has never been repealed. In the House of Commons on the 5th May, 1883, Mr. Watt moved a resolution to the effect:—

"That in the opinion of this House the time has arrived when the Government should appoint a Committee or Royal Commission to take into consideration the question of acquiring the railways of the United Kingdom in accordance with the provisions contained in the General Railway Act of 1844."

The motion was, however, negatived.

It is to be feared that supporters of this proposition have not fully realised the magnitude of the operation they recommend, and nothing is more probable than that, if it ever came to be carried out, the sanguine anticipations of its advocates, as to its financial success, would prove to have been based upon fallacy. The Act of 1844 authorised the transfer of the railways to the State at 25 years' purchase of their average profits for the three years antecedent to the purchase, and this sum would be represented by about *eight hundred and twenty-five millions sterling;* but if ever a scheme of the kind comes within the region of practical legislation, it will certainly not be carried out on the basis of an old and obsolete Act of Parliament, passed at a time when the railway system was in its infancy. To commend itself to the legislature of the present day, and to overcome the strenuous opposition it would undoubtedly encounter, it must proceed upon the principle of equitable treatment of the shareholders of the existing companies, who would have to receive not merely the capital they had sunk in the undertakings, but some reasonable compensation for its prospective value. We believe that if the principle of State purchase were decided upon, it would ultimately have to be carried out somewhat in the following manner :—

As regards the lines that are now earning a profit, Government should guarantee a rate of dividend, which might be taken at the average of, say, three years preceding the purchase, and this would certainly not be putting too high an estimate on their prospective value, which would have a tendency to increase in view of the Government guarantee.

As regards capital invested in railways constructed, but paying no dividend, the question is more complicated. Each case would have to be considered on its merits, but for our present purpose we may assume that the justice of the case would be roughly met by taking this capital at half its nominal value, the Government paying say, $2\frac{1}{2}$ per cent. per annum upon the reduced amount in consideration of their obtaining the possession and control of these lines.

Lines under construction and paying no dividend at the time of purchase might be taken at their nominal value, the Government paying $2\frac{1}{2}$ per cent. per annum upon that amount.

A perpetual Government railway consolidated stock might be created, and the stocks of the different companies be converted into this Government stock on the principle of equivalents; that is to say, that, for example, supposing the Government consols to bear interest at $2\frac{1}{2}$ per cent. per annum, a company whose invested capital was five millions, and who, during the preceding three years had been paying a dividend at the rate of 4 per cent., would receive eight millions of Government bonds.

The following calculation is only an approximate one, but it will afford some indication of the probable financial result of an operation of this kind, supposing it to have been undertaken at the close of the year 1886.*

The total amount of capital (including both share and loan) invested in the railways of the United Kingdom was in December, 1886	£828,344,254
The gross revenue earned in the year 1886 was	£69,591,953
At the present time the capital is earning dividend at various rates, from nothing at all up to 12 per cent.; but the bulk is earning from 3 to 5 per cent., and the amount thus distributed to the shareholders in the year 1886 was	£33,073,706
(The average for the three years 1884, 1885 and 1886 was almost identical.)	
The capital invested in railways constructed but paying no dividend is £55,810,316, upon one-half of which, say £27,905,108, the Government would pay $2\frac{1}{2}$ per cent.	697,627
The capital of railways under construction on which no dividend is paid	

* The Board of Trade returns for the year 1887 are not completed at the time of writing.

amounts to £1,541,444, interest on which at $2\frac{1}{2}$ per cent. amounts to .	£38,536
Total interest payable	£33,809,869
Add working expenses of the railways, which in 1886 were	36,518,247
Total outgoings	70,328,116
As against the gross receipts of	69,591,953
Deficiency	£736,163

There would thus be, instead of the large gains anticipated, an actual loss of nearly a million sterling per annum; but this calculation proceeds upon the assumption that the rates and charges and the gross receipts would be the same as they are at the present time, whereas one of the principal avowed objects of those who recommend State purchase is that, as the profits of the shareholders would be reaped by the Exchequer, the Government would be enabled to reduce the rates and fares for the benefit of the public. Yet if the Government ventured to do this even to the very moderate extent of ten per cent., they would, even after making every allowance for any economy of working that might be effected by the concentration of management, at once find themselves with a deficit of several millions sterling per annum, on the working of the railways, to be made up out of other sources of revenue.

But apart altogether from financial considerations, there are many and grave objections to the scheme, the most important of which may be briefly summed up as follows:—

The State purchase of railways would involve an objectionable amount of interference with the industries of the nation, and with the character of the people. The Government would become the direct employers of a vast army of men of all classes, from labourers to highly trained artisans, clerks and officials; they must come in contact with trades unions, face the question of employers' liability, and all the other difficult labour questions which from time to time agitate the industrial community, and at times they would even have to deal with strikes. In all matters of this kind, they, as a Government, would occupy a very invidious position as compared with the railway companies, who are merely mercantile bodies, dealing with labour as a marketable commodity, under the ordinary laws of supply and demand.

Trade would suffer from the absence of the efforts now put forth by the different railway companies, by granting low rates, constructing branch lines, and by other facilities to develop the competition of markets and to open up new districts.

The Government would be invested with a large amount of patronage, not only in the appointment and promotion of the staff, but in the placing of contracts for coal and iron and other materials, in granting railway facilities, and in many other ways, and they would always be open to the accusation of making use of this patronage for political purposes.

The policy of the railway administration, instead of being guided by one consistent principle, as at present, viz., the improvement and development of the traffic, with which the prosperity of the country is necessarily bound up, would, in all probability alter from time to time, as one party or the other succeeded to office, and this want of continuity would prejudicially affect the management of the railways, and the commercial interests so largely dependent upon them.

All experience of the working and of the scale of expenditure of Government departments is strongly opposed to the belief that so vast and difficult an undertaking as the administration of the railways of the country could be carried on economically and upon sound commercial principles by a department of State. Complaints would be innumerable, and the House of Commons, already overburdened with matters of detail, would, by the multitude of questions to be asked and answered, find its labours so much increased that the business of the country would be seriously interfered with. The traders, who have now the advantage of free access to the officials engaged in the management of the railways—men trained to understand their business and their needs, and willing and anxious to meet their views and assist their operations—would find themselves confronted by the attitude of a Government official, bound inflexibly by hard and fast rules, with no personal discretion, and with, above all, a great disinclination to incur any responsibility.

It only remains to add that in France, where the experiment of ownership of railways by the State has been tried for many years past on a very considerable scale, an agitation is now growing up, as may be gathered from recent debates in the French Chambers, for the absolute sale of the State railways to private companies, on the grounds that the present system involves a very heavy annual loss to the Exchequer, and that any advantages which might be expected to result from the ownership of the railways by the Government are not reaped by the public, but are applied to the furtherance of political objects.

In Belgium, where, as before stated, the railways are worked as a department of the State, and the appointment of Minister of Railways is a political one, the patronage which lies in his gift is well known to be largely exercised for party purposes. Promotion in the service is entirely governed by consideration of the political tendencies of the individuals concerned, and when the Minister is a "Liberal" he will systematically refuse to appoint or promote officials who are known to belong to the "Clerical" party; while, on the other hand, if a "Clerical" Minister is in office, there is no hope of advancement for "Liberals" until their friends, in turn, succeed to power.

In Germany, where there has been considerable experience of the plan of working the railways as a Government Department, the financial result does not appear to be too encouraging. The Railway Department, it is true, figures in the Budget with a large annual profit, but this is only apparent, for the Landtag is every year called upon to vote supplies to be expended on the railways far in excess of the so-called profit, notwithstanding which loud complaints are heard of the want of sufficient plant for carrying on the working in an efficient manner.

The inference drawn from what is taking place in the older countries of Europe is in nowise contradicted by the experience gained from the result of the experiments tried in the new world at the Antipodes. The Victorian State Railways, which, until recently, were managed as a branch of the Government, somewhat on the plan adopted in Belgium, have now been committed to the charge of three commissioners, who are to be freed from all political influences, and to have absolute powers of control, as if the railways were the fruits of private enterprise, as in Great Britain. The same plan is about to be adopted by the Government of Queensland.

CHAPTER XV.

PASSENGER TRAFFIC.

A CONSIDERABLE amount of controversy has taken place during recent years amongst those engaged in the management and working of railways, and also amongst statisticians and others who, as *amici curiæ*, have taken an interest in the subject, upon the question of the relation of the classes one to another, and their relative productiveness from a revenue-earning point of view, and a great deal of diversity of opinion has been shown to exist, even amongst experts, as to the number of classes into which passenger traffic should be divided, the fares which should be charged, and as to what should be the composition, the speed, and the weight of trains, so as to reduce the amount of unprofitable haulage to a minimum, and, while accommodating to the fullest extent the requirements of the travelling public, to secure the best paying load, and preserve a reasonable margin of profit for those whose capital is embarked in the business of conducting railways.

This question—or group of questions—is to form one of the subjects of debate at the forthcoming meeting of the International Railway Congress at Paris, and as the writer has accepted the honour of acting as reporter on that occasion for the English railway companies, and has consequently had occasion to consider the topic with some care, it may be of interest not only to those professionally engaged in the working of railways, but to the public whose interests are largely concerned, to give here some of the conclusions to which he has been led. It is only fair, however, to premise that although the views expressed in the following pages are fully endorsed by some of the leading English railway managers, there are others with whom they find less favour, and they must therefore be taken merely as representing the result of the writer's own experience.

There can, at least, be no question as to the great importance of the subject to all who are engaged in conducting railway traffic, whether in Great Britain or upon the Continent of Europe, since it is a fact that in these modern times the demands made upon railway companies on behalf of the public, not only for the reduction of fares, but for increased speed, more frequent trains, and improved accommodation, have increased, and continue to increase, in such ratio as to render it exceedingly difficult for the companies to keep pace with them without altogether sacrificing the interests of their shareholders. There is, in fact, a great tendency to regard railway companies as monopolists—a reproach to which, in these days of unrestricted competition, few of them are open—and to bring to bear every sort of influence to exact new concessions without any regard to the profit derived, or the loss incurred, in carrying on the business. Thus, while the travelling public benefit, the railway shareholder finds himself filling the doubtless honourable, but not always profitable, *rôle* of a philanthropist, investing his capital for the advantage of the community at large. It may be, perhaps, that on the Continent, where the railways are more or less under

State control, the case may somewhat differ from that of Great Britain, where all the railways have been constructed by private enterprise; but, in the main, the pressure of public opinion will no doubt operate in the same direction, and there will be a constant tendency to require greater and still greater facilities, and thus continually to diminish the revenue-earning powers of the railways. The facts and figures which are here adduced will probably suffice to convince any impartial student of the subject that this process has continued upon the principal railways of Great Britain, to such a degree as to bring about a state of things which can scarcely be defended on sound commercial principles—at any rate from the shareholder's point of view.

Prior to the year 1872 the general practice of all English railway companies was to convey by the mail, and principal fast passenger trains, only first and second class passengers, third class passengers being compelled to travel by less important trains calling at a greater number of stations, or by the Parliamentary trains, so-called, which stopped at every station, and which the companies were bound by statute to run over their lines at least once a day in each direction. For example, in 1872 the Parliamentary train from Euston to Liverpool, a distance of 201¾ miles, started at 7.40 a.m., stopped at every station on the route, and reached its destination at 6.35 p.m., thus occupying nearly eleven hours on a journey which the more fortunate third class passenger of to-day is enabled to perform in four and a half hours. The fares charged at that period averaged 2d. per mile for a first class passenger, 1½d. per mile for second class, and 1d. per mile for third class by Parliamentary trains, while fares at a fraction over 1d.

per mile were charged for third class passengers conveyed by a few fast trains of a secondary character, to which third class carriages were beginning to be attached. At this time the third class carriages, although they were covered in as a protection from the weather, were not upholstered in any way, and contained nothing more than plain wooden seats.

Taking a period of thirteen years, from 1860 to 1872, during which the traffic was conducted under these conditions, a table which has been prepared showing the gross receipts of the London and North Western Railway from each class of traffic, and from the three classes combined, per passenger, and per passenger train mile run, from year to year, gives the following averages for the whole period :—

	Average Receipts per Passenger.	Average Receipts per Train Mile.
	PENCE.	PENCE.
First Class	64·18	16·69
Second Class ...	23·92	17·99
Third Class	13·15	17·62
All Classes combined .	22·17	52·30

Space would not admit of the details of this table being given, but an examination of it shows that from about the year 1869 third class traffic began to assume greater importance, and that the receipts per train mile from this class were gradually increasing; the fact being that the companies about that time commenced to extend the practice of attaching third class carriages to some important trains—other than express trains—while the receipts per train mile from the first and second class had begun to fall off. For instance, in 1868 the first class earnings were 16·05d. per train mile, and the second class 18·05d., while in 1872 they were only 13·21d. and 10·82d. respectively. On the other hand, the third class receipts, which in 1868 were only 16·99d. per train mile, in 1872 had risen to 24·63d. The same causes, however, had led to an increase in the train mileage, which had the effect of reducing the average earnings per train mile, from all classes combined, from 51·09d. in 1868 to 48·66d. in 1872.

In April, 1872, the Midland Company adopted the practice (immediately and necessarily followed by all the other leading railway companies) of conveying third class passengers by all the trains, while nearly three years afterwards—viz., on the 1st January, 1875—they introduced the further innovation of abolishing second class in their trains altogether, and running only two classes, which they termed, rather paradoxically, perhaps, first and third, at the same time reducing the first class fares to about 1½d. per mile. The London and North Western Company did not follow the Midland Company's policy as regards abolishing second class, for the reasons which have been already set forth (see page 125), nor with one or two exceptions, and then only to a limited extent, have any of the other leading railway companies done so, but all were compelled by the exigencies of competition to place themselves on an equality with the Midland Company so far as regarded the re-adjustment of their fares, which was effected by reducing the first class to about 1½d. per mile, and making the second class about 1¼d. and the third 1d.

The striking effect of these changes upon the passenger earnings of the London and North Western Company is very clearly shown by a table which has been drawn up, and which gives the same particulars in respect of the period from 1873 to 1888 inclusive as are given in the table previously referred to, for the period from 1860 to 1872, viz., the gross earnings from each class of traffic per passenger and per train mile. Comparing the average gross earnings of each class for the two periods, we arrive at the following results :—

	Average Receipts per Passenger.		Average Receipts per Train Mile.	
	During period of 13 years—1860 to 1872	During period of 16 years—1873 to 1888.	During period of 13 years—1860 to 1872.	During period of 16 years—1873 to 1888.
	D.	D.	D.	D.
First Class ...	64·18	54·70	16·69	8·46
Second Class ...	23·92	23·05	17·99	6·35
Third Class ...	13·15	11·59	17·62	28·27
All Classes combined ...	22·17	14·97	52·30	43·08

The average receipts per passenger were thus reduced in something like the ratio of the reduction of fares, but the increased mileage consequent upon the greater weight of the trains, coupled with the reduction of the fares, had the effect of reducing the average receipts per train mile from all classes, comparing the two periods, from 52·30d. to 43·08d.

Taking the classes separately it will be seen that while the average receipts per passenger train mile from first class passengers fell in the later period to about one-half what they were in the earlier period, and the second class to about one-third, the receipts from third class traffic were nearly doubled.

But it must not be forgotten that during the last fifteen years other causes, besides the conveyance of third class passengers by all trains, and the reduction of the fares, have been at work in the direction of increasing the cost of the service, and reducing the profits from the conveyance of passengers.

In the first place, there has been a great increase in the speed of the trains generally, and particularly in that of the express passenger trains. For example, in 1872 the fastest trains between London and Liverpool, 201¾ miles, performed the journey in 5¼ hours to 6 hours, while now it is accomplished in 4½ hours. Between London and Manchester, 188¾ miles, the shortest time occupied was 5 hours, while now the distance is covered in 4¼ hours. Between London and Birmingham, 113 miles, one train ran in 3¼ hours, but the others were much longer on the road, while to-day the fast trains all perform the journey in 2¾ hours. But the most remarkable development in the rates of speed is found in the running of the express trains between London and Scotland; and as regards these it will be a sufficiently striking illustration to mention that the 10.0 a.m. Scotch Express from London which, in 1872, reached Edinburgh at 9.10 and Glasgow at 9.30 p.m., now starts from London at the same time but is timed to reach Edinburgh at 6.30 and Glasgow at 6.45. The journey to Edinburgh is thus performed in 8½ hours, and to

Glasgow in $8\frac{3}{4}$ hours, but even this rate is sometimes exceeded, and during the tourist season of 1888 the journey to Edinburgh was accomplished in less than 8 hours, the distance being 401 miles, giving a speed throughout of 50 miles an hour, including all stoppages.

The 8.50 p.m. train from London to Scotland, well-known for many years as the "Limited Mail," and which formerly ran to Aberdeen in 14 hours and 50 minutes, conveying, under contract with the Post Office, a limited number of passengers as well as mails, has been superseded in its functions as the principal mail train from London to Scotland, and since the 1st July, 1885, a special train, conveying no passengers, but only the mails and postal parcels, has left Euston at 8.30 p.m., and reaches Aberdeen at 9.55 a.m., thus performing the journey (540 miles) in only 13 hours and 25 minutes, and travelling at the rate of about 40 miles an hour, throughout, including all stoppages. Between London and Carlisle, this train travels at an average speed of 46 miles an hour.

These exceptionally high rates of speed add to the cost of working in more ways than one; in fact they have a tendency to increase almost every item of expenditure. In the first place, there is a greater wear and tear of the engines and vehicles, and more frequent repairs and replacements become necessary. Secondly, the engines must be worked at much higher pressure, and be of greater capacity, and the increased consumption of fuel, as has already been shown (see page 104), is a very serious item. Then again, to permit of heavy trains being run at such high rates of speed the permanent way must be proportionately strengthened, and becomes more expensive to provide and maintain in the perfect condition which is essential. It is also in a great measure the high rate of speed at which the trains have to be run that necessitates the elaborate and complicated system of signalling and interlocking which has been described in Chapters V. and VI.

Again there has been a very striking increase in the size and weight of the carriages employed for the conveyance of passengers, arising from the popular demand for improved accommodation, and the extent to which that demand has been met.

The standard third class carriage of 1872, for example, was $30\frac{1}{2}$ feet long, and weighed 10 tons, but the standard third class carriage of 1889 is 42 feet in length, and weighs upwards of 18 tons. The carriage of 1872 was capable of seating 50 passengers, but that of 1889 only seats 20 more, or 70 in all, so that while the weight of the vehicle has increased by 80 per cent. the seating capacity has only increased by 40 per cent.—in other words, the weight has increased in double the ratio of the accommodation provided. To take another illustration, the standard composite carriage built by the London and North Western Company in 1872, 30 feet 6 inches in length, weighed 10 tons 8 cwt., but those of the latest type, built recently, measure 42 feet in length and weigh from 18 to 19 tons. These contain lavatory accommodation for the first class compartments, and a cupboard for luggage, and they only provide seats for 44 passengers, as against 36 who could be conveyed in the smaller vehicle of the earlier period.

To keep pace with the increased weight of the vehicles, the power and weight of the engines employed to draw them has also had to be correspondingly augmented. The most powerful passenger engines in use on the

London and North Western Railway in 1872, having driving-wheels 7 ft. 6 in. in diameter, weighed, without tenders, 27 tons 1 cwt.; but the compound engines now being made by Mr. Webb at the Crewe Works, having triple cylinders, and driving-wheels 6 ft. in diameter, weigh $42\frac{1}{2}$ tons; while an even more powerful type of engine on the compound system, having 7-ft. driving wheels, weighs no less than $45\frac{1}{2}$ tons, or, with the tender attached, $70\frac{1}{2}$ tons.

The effect of this increase in the weight and dimensions of the vehicles employed is seen by the diagram given at page 159 (fig. 27), showing the growth which has taken place in the length and weight of some of the typical trains on the London and North Western Railway during the past five-and-twenty years. All the principal trains have been affected in the same way, and of course when trains, under ordinary circumstances, are of such great weight and length, they cannot easily be strengthened to meet any abnormal increase of traffic or sudden pressure, and it becomes necessary, instead, to run extra, or duplicate trains, thus adding in another way to the working expenses. The increased speed has also indirectly had the effect of adding very considerably to the number of trains run, and to the amount of train mileage. In order, for instance, to enable a train to run last year from London to Edinburgh in eight hours, it became not only necessary to maintain a high rate of speed throughout, but very few stoppages at intermediate places could be permitted, and other trains had to be run to serve the stations where the stoppages were omitted, and to enable the passengers from those stations to get on to other stations at which the train did stop.

Another cause which has tended greatly to increase the weight and bulk of the trains is the introduction of saloon carriages of various descriptions, to which allusion has been made in Chapter VIII. (page 126) since these vehicles, although of exceptional weight and dimensions, and extremely expensive to build and maintain, yet accommodate but a very limited number of passengers. For instance, a sleeping saloon 42 feet in length, weighing $22\frac{1}{2}$ tons, and costing £1,300, only contains berths for 16 individuals. A family carriage measuring 32 feet, weighing 15 tons 4 cwts., and costing £820, accommodates eight first class passengers (sleeping) and six second class passengers. The ordinary first class carriages have also lost part of their seating capacity from the fact that no first class passenger in these times is satisfied unless he is provided with lavatory accommodation, and this requirement is being met in building all new stock, so that practically nearly all first class carriages used on the main line are furnished with lavatories. If we take, for example, a first class carriage of the largest size, 42 feet in length, which under ordinary circumstances would provide seats for 40 passengers, with a luggage compartment, we find that, when the necessary space for lavatories has been abstracted, we have only accommodation left for 28 passengers; so that nearly one-third of the accommodation is lost, and the weight of the train is correspondingly increased. It may be added that some of the companies are now commencing to provide lavatory accommodation, not only for first class, as hitherto, but for second and third class passengers also.

Another cause which has a tendency to increase the length and weight of the trains, especially in the busy tourist season, is the growing desire on the part of the travelling public to secure the exclusive use of compartments for a small number of passengers. The companies very generally offer this facility to any one who desires it, subject to the payment of fares as for a minimum number of passengers, viz., four first or second class, or six third class. Great numbers of people, however, seek to obtain the privilege on one plea or another without the payment of the minimum charge, and where the traffic is highly competitive there is a disposition on the part of the companies to make the concession somewhat freely, and often without adequate grounds.

Having thus briefly touched upon the principal causes which have operated during the past fifteen or sixteen years in the direction of reducing the profits derivable from the conveyance of passengers, and more especially of those of the higher classes, it will probably be of interest to refer to certain calculations which have recently been prepared showing (1) a comparison of the receipts from passenger traffic of the three classes carried by the London and North Western Company in the years 1871 and 1888 respectively; (2) the number of *passenger miles* run (*i.e.*, taking the unit of one passenger conveyed one mile, which is arrived at very simply by dividing the gross receipts of each class by the assumed average fare per mile); (3) the cost at which each class has been worked in the two periods; and (4) the net profit derived from each class.

It is found, then, that during the two years mentioned the gross receipts of the London and North Western Railway from passenger traffic (including season tickets) were as follows :—

Year.	First Class.	Second Class.	Third Class.	Total.
1871	£758,665	£903,627	£990,051	£2,652,343
1888	550,535	366,552	2,487,532	3,404,619
Increase	...	...	1,497,481	752,276
Decrease	208,130	537,075	...	...

So that the first class receipts decreased 27 per cent., and the second class 59 per cent., while the third class *increased by* 151 *per cent.*, the total increase from all classes being 28 per cent., while within the same period the capital invested in the undertaking increased to the extent of about 46 per cent.

The *passenger miles* (not to be confounded with *passenger train miles*) calculated in the manner above described by assuming the average fares to have been :—

	First Class. D	Second Class. D	Third Class. D
In 1871 ...	1·80	1·35	·90
In 1888 ...	1·50	1·25	·90

give the following results :—

Year.	First Class.	Second Class.	Third Class.	Total.
1871	101,155,333	160,644,800	264,013,600	525,813,733
1888	88,085,600	70,377,984	663,341,867	821,805,451
Increase	...	...	399,328,267	295,991,718
Decrease	13,069,733	90,266,816	...	...
	12·9 %	56·2 %	151·3 %	56·3 %

So that while the total receipts from all three classes shew an increase of only 28 per cent., the work done, measured by passenger mileage, has increased by just twice that amount, viz., by 56 per cent.

If the reader will now refer to the figures given at page 125, he will find that the number of seats provided in the company's carriage stock at the present time is :—

First Class	22,067
Second Class	22,506
Third Class	119,500
	164,073

In 1871 the numbers were :—

First Class	19,462
Second Class	28,768
Third Class	44,960
	93,190

Thus the accommodation has in the aggregate been increased by 76 per cent., while the gross receipts, as stated above, have only been augmented by 28 per cent., which shows—assuming that the carriage stock provided in 1871 was proportionate to the requirements of the traffic—that under present conditions the trains are not so well and fully occupied as under the old state of things, and that unprofitable mileage of carriage stock is being run.

It has always been a somewhat vexed question amongst railway statisticians as to what is the most reliable method of arriving at an estimate of the relative net profits derived from the various classes of passenger traffic; that is to say, that, having ascertained the total cost of working the traffic as a whole, the difficulty is to find a sure basis upon which to apportion it between the three classes. The number of passengers carried is obviously not a safe guide, because it is necessary to take into consideration the wide difference in the conditions under which they are conveyed. To divide the amount in proportion to carriages employed is impracticable, because a great number of the carriages contain accommodation for all three classes in varying proportions. The number of seats provided in the carriages employed is a somewhat more reliable basis; but even this leaves something to be desired, because a first class seat occupies more space in a train, and adds more to its weight than a second class seat, while even a second class seat occupies more space than a third. In addition, the lavatories for first class, and the great size and weight of the saloons of various descriptions have to be reckoned with.

After very careful consideration of the subject, the writer has arrived at the conclusion that the nearest approximate results are to be obtained by apportioning the total passenger working expenses betwen the three classes in the ratio of the *seat space* occupied in the entire carriage stock of a company, and a calculation made upon this basis, with regard to the passenger traffic of the London and North Western Railway in 1888, and in 1871, the last year before the introduction of the changes which have been enumerated, gives the following results:

Year.	First Class.		Second Class.		Third Class.	
	Working Expenses per cent.	Net profit per cent.	Working Expenses per cent.	Net Profit per cent.	Working Expenses per cent.	Net Profit per cent.
1871	53·00	47·00	51·55	48·45	36·35	63·65
1888	92·05	7·95	72·55	27·45	42·25	57·75

If it be assumed that these figures are approximately correct, and that the principle adopted in arriving at them is theoretically sound, which there is probably not much reason to doubt, their significance can hardly be exaggerated. It will be seen that the net profit on first class traffic, which, in 1871 was nearly half of the gross receipts, has by reason of the reduction of fares and the greatly enhanced cost of working (from causes which have already been dwelt upon) diminished until in the year 1888, it represents not quite eight per cent. of the gross receipts. The profit upon second class traffic, which, in 1871 was also nearly half the receipts, has now, from the same causes, dwindled to little more than a quarter, while even the profit on third class traffic has fallen off to some extent, although not so seriously, owing to the fares remaining practically undisturbed.

Another calculation shows that the net earnings per passenger per mile, after payment of working expenses, for the two periods under comparison, were approximately, as under:—

	First Class.	Second Class.	Third Class.
	D.	D.	D.
1871	·85	·65	·57
1888	·12	·34	·52

So that, under the old state of things, the first class traffic paid best, but the second class paid better than the third; while, under present conditions, the third class is the most remunerative traffic, the second class comes next, and the profit on first class appears to be very small indeed.

During the period of eighteen years which has elapsed between the years 1870 and 1888, although the mileage of railways owned and worked by the London and North Western Company has only increased to the extent of forty-five per cent., the passenger train mileage has increased by sixty-one per cent., and the gross amount of fuel consumed per annum by passenger engines has been augmented by no less than 142 per cent., or in more than double the ratio of the increase of train mileage, showing the unmistakeable effect of the increased speed, and the heavier weights to which motive power has to be applied. The total number of passengers carried has increased, it is true, by eighty-seven per cent., but the earnings have only been improved to half that extent, or by forty-four per cent., while the number of passengers conveyed for the expenditure of one ton of fuel has fallen by 22 per cent.—that is to say, that the amount of fuel, which in 1870 was sufficient to convey 100 passengers, in 1888 only sufficed to convey about seventy-eight, owing to the greater amount of dead weight to be hauled, and the higher speed to be maintained.

Mr. Price Williams, Mem. Inst. Civil Engineers, who has achieved a considerable reputation as an indefatigable statistician, and an authority on most questions relating to railways, submitted to the writer, about four years ago, some very interesting calculations which he had prepared with the view of demonstrating what he believed to be the unproductive character of the first and second class traffic upon the principal railways, consequent upon the altered policy which had been brought about since 1873, and to which reference has been made. These calculations assumed the form of an analysis of the passenger receipts and working expenses of the London and North Western Railway during a long period of years, viz., from 1860 to 1884, and as they impressed me very much at the time as showing striking results, and bearing out to a great extent the conclusions at which I had already arrived, it may be worth while to give a brief abstract of them in this connection.

Mr. Williams' figures, which were most carefully prepared, showed that from 1860 to 1871 the net profits from first and second class continued to be over 50 per cent. of the gross receipts, although the average gross receipts per passenger and per train mile were gradually reduced. In 1873, the first year in which the policy of attaching third class carriages to all trains was brought fully to bear, although the gross receipts from first-class traffic continued to increase, there was a larger growth in the working expenses, and the first class net receipts therefore fell off from 2s.9½d to 2s. 3¼d. per passenger, and from 7⅓d. to 5¾d. per train mile. The second class suffered to an even greater extent, the number of passengers of that class having decreased from 8,281,366 in 1871 to 5,418,494 in 1873, and the gross receipts from £867,099 to £557,200. The second class net receipts fell from 1s. 3d. per passenger to 9d., and the net receipts per train mile from 10d. to not quite 4d. The third class receipts, as might have been expected, were very largely increased.

Coming to the year 1875, the year in which second class was abolished on the Midland Railway, and the fares were consequently reduced, as previously described, we find that, although the number of first class passengers conveyed by the London and North Western Company reached its maximum of 3,288,661, the net receipts were, owing to the reduction of the fares, only 1s. 6½d. per passenger, and 4d. per train mile, as against 2s. 3d. per passenger, and 5d. per train mile in 1873. The second class net receipts, from the same cause, were similarly affected.

From 1875 to 1881 the number of first and second class passengers and the receipts continued rapidly to decrease, and the third class to increase, in a remarkable degree. The net receipts from first class fell from 1s. 6½d. to 1s. 2d. per passenger, and from 4d. to 2d. per train mile, and in the second class, although the gross receipts per passenger were slightly increased, the net receipts were reduced from 5d. to 4d. per passenger, and from 2½d. to less than a penny per train mile.

The figures for the last period compared, from 1881 to 1884, continue to show the same tendency, but in an accelerated degree, the effect of the decrease, year by year, in the first and second class gross receipts, combined with the increase in the working expenses, being to still further diminish the slender profit upon these classes of traffic, until we find that in the year 1884 the net profit per first class passenger has come down to 5·71d., as against 3s. 5d. in 1860, and from 11d. per train mile to ·68d. The net profit upon each second class passenger, which in 1860 was 1s. 2d., in 1884 has fallen to 2d., and the net profit per train mile has been reduced from nearly a shilling to less than a halfpenny.

It will be seen that the tendency of these figures, although they have been compiled by a different hand, and arrived at by a different process, is to confirm the conclusions based upon the more recent calculations prepared under the writer's directions, and which have already been quoted, and to show that the altered conditions under which the business is carried on have contributed to render the profits derived from first and second class very small indeed, and that the companies must now look chiefly to the third class traffic for their revenue. In fact, in contemplating the returns for a series of years, nothing is more striking than the enormous and uninterrupted growth in the number of third class passengers from year to year, no matter how the other classes may fluctuate. The companies, in short, have spent and are spending large sums of money in providing the most luxurious accommodation, and every facility and convenience for the benefit of the superior classes, but they are doing this practically at their own expense, and it is really the humble and once despised third class traveller who furnishes the sinews of war. It must be borne in mind, moreover, that although the figures show a profit, however small, upon the carrying of first class passengers, this result is only arrived at as an average, by treating all first class passengers alike, and while it may still be a profitable business to carry first class season-ticket holders, or passengers by local and suburban trains, it may well be doubted whether, under present circumstances, upon first class passengers carried long distances by express trains—say between London and Scotland—there is any profit at all.

On the whole, therefore, it would appear that the revenue to be derived from the conveyance of passenger traffic upon English railways is a diminished and diminishing quantity, and that it is only the fall during recent years in the value of materials, especially of coal, and other favourable circumstances, that have enabled the principal companies to fairly maintain their dividends ; while if the present conditions with regard to passenger traffic remain unaltered, and there should be any material rise in prices of stores, or loss upon the working of the goods traffic by reason of bad trade, or if there should be any considerable reductions of the Parliamentary powers of the companies, which are now undergoing revision at the hands of the Board of Trade in conformity with the Railway and Canal Traffic Act of last Session, then the outlook for railway shareholders would be a serious one for them to contemplate.

There seems to be no reason to doubt that the state of things thus described, so unfavourable from the railway shareholders' point of view, has been brought about chiefly by reason of the lengths to which the companies have gradually proceeded, under the pressure of competition, in making concessions without adequate remuneration for the privileges bestowed. These concessions have certainly been very great, and they have had the effect of placing railway travellers in Great Britain in an extremely favoured position as compared with the public who use the Continental railways, since there need be no hesitation in saying that although the methods of working in France, Belgium, Germany, and Austria may be sufficiently well adapted to the circumstances of those countries respectively, they are not such as would commend themselves to the British public. On most Continental railways the express trains carry, as a rule, only first and second class passengers, and the fastest trains travel, on an average, ten miles an hour less than the express trains in England. The permanent way—constructed with Vignoles, or flat-bottomed rails bolted to the sleepers, without chairs, and weighing considerably less to the yard than the rails commonly in use in this country—is not adapted to bear the enormous strain which would be imposed upon it by long and heavy trains running at the high rates of speed which prevail upon English railways.

It is evident that the readiness of English railway companies to yield to the demands of the public, and to proceed from one concession to another, has arisen from the peculiar nature of the traffic of a country of limited extent like Great Britain, and where the business is so extremely competitive. Most of the railways in Germany, Austria, and Belgium are either State railways, or are controlled more or less by the State, and are worked not only for the benefit of the travelling public, but with an eye to the improvement of the State revenue; and in France, although the principal railways have been constructed by private Companies, it has been done upon a system of territorial concession for a period of time, the State reserving a control over the fixing of the rates and charges, so that the question of competition seldom arises. In England, on the contrary, the Legislature has fostered the principle of competition by sanctioning the construction of railways forming alternative routes between most points of importance. For instance, between London and Manchester there are three routes open to the intending traveller; between London and Liverpool there are three, between London and Edinburgh, Glasgow, Perth, or Aberdeen, three; between London and Leeds, three, between Liverpool and Manchester three, between London and the principal places in the West of England two; and so on throughout the country.

From London to Manchester the London and North Western Company are running 16 trains daily, the Great Northern Company are running 8, and the Midland Company the same number. From London to Liverpool the North Western Company are running 13 trains daily, the Midland Company 9, and the Great Northern Company 6. From London to the principal places in Scotland, the North Western Company run 8 trains daily, the Midland Company 6, and the Great Northern Company 6. Between Liverpool and Manchester the London and North Western Company run upwards of 20 express trains a day in each direction, the Cheshire Lines Committee run about 25, and the Lancashire and Yorkshire Company will shortly be running about an equal number. Many of these trains run at the same times, or nearly so. For example, both the North Western and Great Northern Companies have trains leaving London for Scotland at 10 a.m., and the Midland Company have a similar train only half-an-hour later. By three different routes a train leaves Liverpool for London at or near 4.0 p.m., and such instances might be multiplied indefinitely, the trains in most cases performing the journey in about the same time, and at precisely the same fares. The traffic is thus acutely competitive, and the conditions being so equal, it requires but a trifling inducement to influence the travelling public in the choice of route, so that there is a constant temptation to the competing companies to make fresh concessions so as to attract the business from their rivals; and as any new departure by one company is immediately followed by its competitors, it becomes at once stereotyped, and merely forms a basis for still further concessions.

It may be, of course, that during the busiest season —extending over four or five months of the year—there is sufficient traffic to utilise the whole of the trains run by the various routes; but there is no doubt that during the remaining seven months the accommodation provided is, in the aggregate, far in excess of the requirements, and that, as a matter of fact, the trains are frequently run with very few passengers in them, doing little more than paying their expenses.

So far as the public are concerned there is, of course, in all this nothing to be complained of; but if it be asked from a railway shareholder's point of view, what is the remedy for the loss of revenue which has been indicated, although it is not impossible to find an answer to the question, the solution of the problem is one involving many difficulties. As regards increasing the traffic greatly beyond its present volume, there is probably not much to be hoped for, the country being limited in extent, and the possibilities of expansion being circumscribed by the amount of the population, although it will, naturally, always fluctuate with the prosperity of the country. The only thing to be done in this direction is to follow out the policy which has already been adopted by most of the companies, of granting low fares and season ticket rates between all the large centres of population and places within a radius of about twenty miles, so as to build up a residential traffic, by encouraging the people to live in the healthier suburbs instead of in the large towns in which they pursue their avocations. As regards long distance traffic it is very doubtful whether the reduction of fares, or any other concessions, tend to materially increase the volume of business; as a rule people do not take long journeys unless they are called upon by actual necessity to do so, and in that case they will travel, whatever the fare may be, within reasonable limits. Of course, however, this remark is not intended to apply to the traffic between large towns and seaside or other holiday resorts, which all the companies encourage by granting return tickets at low fares during the summer months, this being a case in which, by judicious concessions, a traffic is created which would not otherwise exist to anything like the same extent.

A return to the earlier practice of conveying third class passengers only by secondary trains, combined with a general reduction of speed, is practically out of the question, for if anyone were sufficiently bold to propose any such retrograde policy, it would encounter the strongest tide of public opinion in opposition to it, and it would be impossible to get all the companies to adopt and adhere to it in the face of the pressure which would be brought to bear upon them. For good or evil these concessions have been granted and cannot now be withdrawn, and it only remains for the railway companies to make the best of the situation as it exists, and to endeavour to protect themselves against further losses. In the end, it seems probable that the companies, if they are wise, will achieve this object by some kind of combination amongst themselves by which excessive competition may be obviated, and two or more companies carrying between common points may be enabled to reduce their train mileage, to curtail the running of unprofitable trains and a great deal of unnecessary expenditure, and to keep the speed of the trains within reasonable limits, so as, without lessening the accommodation afforded to the public, to preserve conditions under which the business of carrying passengers may again be conducted with a fair margin of profit to those whose capital is engaged in it.

CHAPTER XVI.

On the Law as between English Railway Companies and the Public.

It is not the writer's intention, under this heading, to enter upon a minute examination of the whole body of what is known as "Railway Law." The limits of the present work would not indeed admit of this, nor is it necessary, for books of reference already exist, edited by competent hands, and affording the widest information upon all the legal questions which can arise in connection with railways. These are, however, for the most part overlaid with legal formulæ, references to case law and Acts of Parliament, and contain a great deal of matter which can possess no interest for the general reader; so that, without in any way trenching upon their province, it may be useful to give here a brief summary, in "language to be understanded of the people," of the most important provisions of the laws which govern railway companies in their daily dealings with the public. It has been said that a little law, like a little knowledge, is a dangerous thing; and it has been likewise remarked that "the man who is his own lawyer has a fool for his client"; but all this proverbial philosophy must be taken *cum grano*, and it may well be that a little intelligent appreciation of the state of the law on a given subject may suffice to keep a man out of the law courts when a resort to litigation could only end in the loss of time, temper, and money.

The law as affecting railways is defined in various ways. There are, first, the provisions of the special Acts authorising the making of the several railways ; secondly, the various public Acts which have been passed from time to time for the regulation of railways ; thirdly, there is what is known as common law, or the custom of the realm ; and in addition to all these, there is a great body of what is called "case law," that is, the recorded decisions which have been given by the Courts at different times upon disputed questions involving the interpretation of Acts of Parliament. In the remarks that follow, we shall treat all these authorities as one for our purpose, and merely attempt to give the reader some idea of what, in the present state of the law, he has a right to demand from the railway companies in his dealings with them, and what, on the other hand, they are entitled to expect from him.

In considering railway law, nearly every thing appears to turn upon the great question of what constitutes a "common carrier," and if this point is once clearly established in a given case, the rights, liabilities, and immunities of a common carrier are pretty clearly defined by the authorities. We learn, then, that a "common carrier" is one who undertakes the conveyance of goods or passengers for hire or reward, and therefore stands in the light of a bailee. He must exercise the business of carrying as a public employment, and must undertake to carry all persons, or the goods of all persons, as the case may be, indiscriminately. Having become a common carrier, as thus defined, the law places upon him the *duty* *to carry*, according to his profession, though there may be no specific agreement as to the performance of the service, or the price to be charged for it, and, with certain reservations, which will be noticed hereafter, he becomes an *insurer*, and is liable for loss or damage, unless such loss or damage arises from the act of God or the Queen's enemies.

Legally speaking, railway companies are not common carriers unless they choose to constitute themselves as such. The Railway Clauses Consolidation Act of 1845 provides that it *shall be lawful* for a railway company to employ engines and carriages and convey passengers and goods, but it does not say that they *shall* do so. Thus some of the earlier railway companies simply allowed other people to run their own engines and carriages over the railway on payment of tolls, and they were not common carriers; but so soon as a railway company exercises its discretion under the Act of 1845, and holds itself out to the world as a common carrier, it comes within the operation of all the provisions of carrier's law, which, with some variations, applies equally to all other means of conveyance, whether by land or water.

A railway company is not entitled to make any charges for the services it performs, in excess of the charges specified in the Acts relating to its undertaking.

From this point it will be convenient to divide the remarks which follow under two heads, viz., (*a*) as to the law affecting the carriage of merchandise (in which term is included coal and other minerals, and live stock); and (*b*) as to the law affecting the conveyance of passengers and their luggage.

(*A*.)—As to the Law affecting the Carriage of Merchandise.

(1.) A common carrier, as a general rule, is bound by the common law to receive and carry, to those places which he holds himself out as carrying to, all goods offered to him for that purpose, from all persons alike upon the tender of payment for his hire; and if he refuses to do this, an action is maintainable against him. It must, however, be proved that he had the *means* of carrying the goods; that, in the case of goods of great value, he had the means of carrying them *securely*, and that they were offered to him at a reasonable time.

He is only liable to carry to such places as he holds himself out to be a common carrier to and from, and then only to carry such descriptions of goods as he professes to carry. As will be seen hereafter, there are certain articles of which railway companies are not, and decline to be, common carriers.

(2.) A carrier may refuse to take the custody of goods unless he is previously paid the price of their carriage. Railway companies, as a matter of practice, charge the carriage forward, if so desired, and collect it from the consignee, and in some cases they allow ledger accounts and collect their freight charges monthly; but, in so doing, they waive their rights in order to meet the convenience of their customers.

(3.) The responsibility of a carrier commences on the delivery of the goods to him and continues until he has delivered them or tendered them for delivery to the consignee. Many actions at law have turned upon the question of what constitutes "delivery" to a carrier, and the point is one of some delicacy; but, speaking generally, it may be said that the goods must be delivered by the sender or his accredited agent actually into the hands of the carrier, or some person who can be shown to be his agent, for the purpose of receiving them; for instance, his carman or the keeper of one of his receiving offices.

(4.) Goods delivered to a carrier must be properly and securely packed, and if any injury arises to them during their conveyance from their being, unknown to the carrier, improperly or insufficiently packed, the carrier is absolved from liability.

(5.) If any fraud or deceit be practised on the carrier whereby the real value of goods is concealed from him, and he is induced to regard them as of comparatively trifling value, he is not liable in case they be lost or stolen from him.

(6.) Railway companies are not bound to carry articles of a dangerous nature, such as gunpowder or other explosives, or lucifer matches; and if a person sends such articles by railway without declaring their true nature, he is liable to a penalty. The company may refuse to accept any package which they have reason to suspect contains goods of a dangerous nature, or to require that the package shall be opened so as to ascertain the facts.

Railway companies are not common carriers of articles of this description, and only convey them by arrangement with the senders, and under proper regulations.

(7.) At common law a carrier is in the nature of an insurer, and is bound to keep and carry goods entrusted to his care safely, and is liable for all losses, and in all events save only, as before mentioned, those resulting from the act of God or the Queen's enemies; and this holds good notwithstanding that there may have been no actual negligence on his part, and that the injury or loss may have been occasioned by the act of a third party. The "Act of God" has been defined as being something in opposition to the act of man, as for example, winds and storms, lightning, earthquake, inundations, or sudden illness or death, the consequences of which could not by any reasonable precautions on the part of the carrier have been prevented. "The Queen's Enemies" means *foreign* enemies, who are such by open declaration of war; not domestic enemies, as in the case of insurrection or riot, where the carrier, if made liable, would have his remedy in turn against the county.

(8.) The carrier is liable for the loss of goods occasioned by fire while in his possession as a carrier, notwithstanding that the fire may not have originated on his premises, or been caused by his negligence; but if the carrier is merely acting in the capacity of a warehouseman for the owner of the goods, the liability of a common carrier will no longer attach to him.

(9.) A carrier is not liable for losses or damage arising from the ordinary deterioration of goods in quantity or quality during transit, or from their inherent tendency to decay or deteriorate, or from accident occurring to any animal through its own inherent vice.

(10.) At a very early period in the history of railways, viz., in 1830, an Act was passed, which, although at the time intended for the protection of coach proprietors, mail contractors, and other carriers by road, was, by the 89th section of the Railways Clauses Consolidation Act of 1845, extended to railway companies in their capacity as common carriers. This Act (I. Will. IV. cap. 68) is popularly known as the "Carriers' Act," and it has a very important bearing upon the liability of a railway company for loss of, or damage to, valuable goods entrusted to its care.

The principle of the Act is contained in the first and second clauses, which provide that no common carrier by land for hire shall be liable for the loss of, or injury to, any articles of the following descriptions, viz.:—

Gold or silver coin.
Gold or silver in a manufactured or unmanufactured state.
Precious stones.
Jewellery.
Watches.
Clocks and timepieces.
Trinkets.
Bills.
Bank notes.
Orders, notes or securities for payment of money.
Stamps, English or Foreign.
Maps.
Writings.
Title deeds.
Paintings.
Engravings.
Pictures.
Gold or silver plate or plated articles.
Glass.
China.
Silks, manufactured or unmanufactured, and whether wrought up with other material or not.
Furs.
Lace.

whether delivered to be carried for hire or to accompany the person of a passenger by any public conveyance, when the value of such article exceeds ten pounds, unless at the time of delivery to the carrier the nature and value of such articles shall have been declared by the sender, and he shall have paid, or agreed to pay, such additional charge, over and above the ordinary rate of carriage, as the carrier shall, by notice, demand as compensation for the greater risk and care to be taken for the conveyance of the articles. In plain terms, the carrier is not liable unless the sender declares the value and pays the charge for insurance fixed by the carrier, and railway companies give effect to this Act by fixing an *ad valorem* scale of insurance for the articles named in the Act, this scale being duly advertised in their time tables and by other means.

By an amending Act, passed in 1865, it was enacted that the term "lace" should be construed so as not to include machine-made lace. It should also be mentioned that the Act of 1830 limits the carrier's liability to the declared value of the goods, plus the additional charge for insurance, but does not preclude the carrier from reducing this liability by proving that the declared value exceeds the actual value, if such be the case. Further, as the intention of the Act, as stated in its preamble, was to protect the carrier from the risk of depredation of articles of great value in small compass, it very properly provided that, where such depredation was committed by the servants of the carrier, he should be liable notwithstanding any of the provisions of the Act.

(11.) When railway companies first commenced to carry horses, cattle, sheep, and other live stock, they were in the habit of giving notice to the senders that they were not common carriers of live stock, and that they only conveyed it on the understanding that the owners took the entire risk, and this notice, being printed on the ticket, was held by the courts to be a special contract, and legal and binding upon both parties; but by an Act passed in 1854, entitled, "An act for the better regulation of the traffic in railways and canals," it was provided that in future all conditions limiting the liability of railway companies should be void unless they were reasonable, and were signed by the consignor, with a further proviso limiting the liability of railway companies for loss of, or injury to, animals and live stock committed to their care, to the following amounts :—

For any horse,	not exceeding	£50.
„ neat cattle, per head	„	15
„ sheep or pigs, per head	„	2

The companies are exempted from liability for any greater sums than these, unless the sender shall declare the value of the animals at the time of delivery to them, and pay a reasonable charge for insurance, to be fixed by the company, over and above the ordinary rate of carriage. In point of fact, the principle of the "Carriers' Act" is, with certain limitations, applied to the conveyance of live stock.

(12.) By an Act passed in 1845 the railway company is empowered, in any case where they fail to recover the charges payable for the carriage of goods, to detain and sell the goods, and to retain out of the profits of the sale the amount due to them for freight, rendering up the surplus, if any, to the owner of the goods. The carrier may, however, sue for his carriage and is not obliged to rely entirely upon his lien on the goods where they are not equivalent in value to the amount of the freight.

(13.) A railway company is also entitled to retain possession of the goods until the amount due for freight has been paid.

(14.) We have seen in clause 3 that the liability of a carrier terminates only on the goods being delivered up out of his custody to their owner, but this requires a little elucidation. The law provides that if the terms of the carrier's contract with the sender necessitate his transferring the goods to another company or conveyance in order to complete their transit, he is liable throughout, and the company or person to whom he hands them at the termination of their transit over his own railway is looked upon as his agent; but where, by the terms of the contract, his own duty is complete and the goods have passed out of his hands, the liability is transferred to the third person, until the delivery of the goods is completed.

Practically, this means that if the goods are booked and the carriage paid *throughout*, the contracting company, in the absence of any special condition to the contrary, is liable for the whole journey; but if the contracting company book the goods and are paid the carriage from A to B only, and there, by the instructions of the sender, hand them over to another company or carrier to convey from B to C, the liability for the latter portion of the journey rests with the carrier from B to C.

(15.) It is the duty of a carrier to deliver the goods within a *reasonable time* according to the usage of trade, the ordinary course of business, or the terms of the contract.

(16.) We have seen that the responsibility of the carrier continues until he has effected delivery of the goods to the consignee, but much litigation has from time to time arisen as to what constitutes a good delivery. The point is one involving some difficulty, but the following principles have been laid down:—

(*a.*) The carrier is bound to deliver the goods at the place of business, or residence of the consignee, provided it be known to him, and that he has been paid a charge which includes delivery from the receiving station to the consignee's address.

(*b.*) If the carrier tenders the goods for delivery at consignee's residence or place of business, and the latter is not in a position to pay for their carriage, the carrier's liability is at an end, as he is not bound to bring them a second time. The consignee must fetch them away when he is in a position to pay the carriage.

(*c.*) Where it is not part of the duty of the carrier to deliver the goods to the consignee's residence, as in the case of goods carried at station to station (*i.e.*, *not carted* rates), or where the consignee's residence or place of business is beyond the recognised limits of delivery, the carrier is bound to give notice to the consignee of the arrival of the goods; and when a reasonable time for their removal has elapsed, the liability of the carrier for loss or damage ceases, and he is, in law, held to have effected a constructive delivery.

(17.) If the carrier delivers goods to any other than the person entitled to receive them, he is liable to the proper owner for their value.

(18.) The sender of goods has a right of what is called "stoppage in transitu," which may be exercised in the following circumstances:—If goods are sold upon credit and delivered to a carrier to be conveyed to the buyer, and if, while the goods are in transit, the buyer, not having paid the whole of the purchase money, becomes bankrupt, or fail, or stop payment, the sender may countermand the consignment, and require the goods to be re-delivered to himself, of course upon payment of the carriage.

(19.) When goods have been delivered to a carrier for conveyance the property in them is vested in him for the time being, and he is not obliged to give them up again until he has been paid his charges. Even if the sender changes his mind and does not require them to be forwarded, the carrier may still demand his hire, because by taking the goods into his custody he has already incurred risks. The carrier, while he is liable to the owner for the safety of the goods, may maintain an action at law in his own name against a third party who takes them out of his possession or damages them, just in the same way as a letter while in transit through the post, is held to be, at law, the property of the Postmaster-General.

(20.) When goods are directed to be left with the carrier until called for, and the consignee does not remove them within a reasonable time, the carrier is entitled to make a charge for warehousing them.

(21.) In an action against a carrier for loss of goods the amount to be recovered depends upon the extent of the carrier's liability, *i.e.*, upon whether he is liable for the whole value of the goods, or whether his liability has been limited by Act of Parliament (as, for instance, in the case of a horse carried at the uninsured rate), or by any special contract. If no special damage can be proved, the plaintiff cannot recover beyond the value of the goods.

In the case of the non-delivery of goods, a plaintiff is entitled to recover the value of the goods at the place of delivery, at the time at which they ought to have been delivered, so that, in the case of goods sent to a market, the plaintiff is entitled, not merely to the cost price, but to the market value; and in the case of delay in delivery, he is entitled to recover any difference between the market value at the time when the goods ought to have been delivered and at the time when they were actually delivered.

In other cases, special damages for delay may be recovered even when the article delayed has suffered no deterioration in value, as, for instance, when the company has accepted the goods with notice that their non-delivery by a specified date will defeat the object with which they are sent; but only such damages can be recovered as must be taken to have been within the contemplation of the parties to the contract of carriage when such contract was entered into, and as might reasonably be expected to result from a breach of such contract.

(*B.*)—AS TO THE LAW AFFECTING THE CONVEYANCE OF PASSENGERS AND THEIR LUGGAGE.

(1.) A railway company, having constituted itself a carrier of passengers, is bound to convey upon its railway all such passengers as may offer themselves for that purpose, without unreasonable delay, and without partiality, and if a railway company issues time-tables and advertises that a train will run at a particular time, this amounts to a contract on their part to run the train and convey all persons who offer themselves as passengers, provided they are prepared to pay the usual fare, and that there is room in the train.

(2.) The passenger must be in a fit and proper state as to sobriety, health and conduct, so as not to cause offence or danger to the other passengers. A railway company is not compelled to convey upon their railway a person who is intoxicated or insane, or who is suffering from an infectious disease. A passenger is also bound to submit to all reasonable regulations which may be adopted for the convenience, safety and comfort of the public.

(3.) By an Act passed in 1883, called the "Cheap Trains Act," it is provided that if at any time the Board of Trade have reason to believe that upon any railway or system of railways, whether belonging to one company or more than one, but which forms a continuous mode of communication, a due and sufficient proportion of the accommodation provided is not available for passengers at fares not exceeding one penny per mile, or that upon any passenger railway proper and sufficient workmen's trains are not provided for workmen going to and returning from their work at such fares and at such times between 6 p.m. and 8 a.m. as appear to the Board of Trade to be reasonable and necessary, they may hold an enquiry, and, if called upon to do so by any railway company concerned, may refer the matter for the decision of the Railway Commissioners. If the result of the enquiry is to prove to the satisfaction of the Board of Trade or of the Railway Commissioners that such proper accommodation is not provided, then the Board or the Railway Commissioners, as the case may be, may order the company to provide such accommodation, and at such fares as seem to them reasonable.

As a matter of fact, this power has, on several occasions, been exercised by the Board of Trade since the passing of the Act.

(4.) A railway company, in carrying passengers, is not subject to the same liabilities as apply to a common carrier of goods. It has been shown in the first portion of this chapter, that as to goods the carrier is in the position of an insurer, and is liable in all events except the act of God or the Queen's enemies, but he is not called upon absolutely to *warrant* the safety of the passengers. He only undertakes that so far as human care and foresight can go he will provide for their safe conveyance; he is to use the utmost care and diligence, and is responsible for the consequences of the slightest neglect on his part, but his liability goes no further. Thus, in a case where an accident occurred through the breaking-down of a bridge the Court held that if the bridge was constructed by a competent engineer, and of reasonable and proper strength for the purpose, and was maintained with due care and skill, the company was not liable.

(5.) A railway company is responsible for the negligence or default of its servants *within the scope of their legitimate employment* as if their acts were its own. Thus, if a signalman causes an accident by giving a wrong signal, the company is liable; but if a porter or telegraph boy were to mischievously, or without authority, interfere with the signals, or with an engine and cause an accident, the company would not be liable.

(6.) A railway company is bound to carry free, with each passenger, his personal luggage to an amount fixed by the Acts of Incorporation of the several railway companies, according to the class of carriage in which the passenger travels. This amount varies in different Acts, but, in practice, the railway companies carry free 120 lbs., 100 lbs., and 60 lbs., for 1st, 2nd, and 3rd class passengers respectively, and the company's liability with respect to passengers' luggage is the same as that with respect to goods entrusted to it for conveyance, so long as the passenger's luggage is under the charge of the company. If, however, the passenger takes the luggage under his own control, the company's liability is diminished, and only arises where negligence is shown on the part of its servants.

(7.) The question of what constitutes personal luggage has been the subject of many judicial decisions, but, broadly speaking, personal luggage may be defined as consisting of such articles as the passenger requires for his own use or personal convenience upon or in connection with his journey, although more recent decisions have included articles which might not perhaps fall strictly within that definition.

As a negative definition, however, it may be said that personal luggage does not include merchandise and materials intended for trade purposes.

(8.) The provisions of the Carriers' Act apply equally to passengers' luggage as to goods, and the foregoing remarks upon the subject of that Act may be taken as referring to both, with the additional observation that, though the Act protects the carrier from loss or damage under the circumstances stated, it does not protect him from the consequences of delay, unless the delay is such as to practically amount to a loss even though the articles are eventually recovered.

(9.) If a passenger travels upon a railway without paying his fare, or travels a greater distance than that for which he has paid, and there is evidence that he has acted with a fraudulent intent, he is liable to a penalty, and may be detained by any officer of the company, or by any peace officer, until he can be brought before a justice for the purpose of punishment. If there is no evidence of fraud, the company have no right to detain the individual or to use force to expel him from the train after he has commenced his journey; their proper course is to exercise the right, which they possess, of lien on his luggage for payment of the fare, or to sue him in a court of justice.

(10.) Under the bye-laws of railway companies which they are by Act of Parliament empowered to make, and which are legal and binding, a passenger is bound to show his ticket when requested to do so by any servant of the company.

(11.) In an action against a railway company for refusing to carry, or for not carrying, a passenger within a reasonable time, the plaintiff, on proof of negligence, is entitled to recover any extra expense he may have reasonably incurred in reaching his destination by other means, and he may also, within certain limits, recover damages for any loss or expense which he may have sustained by reason of the delay; but the extent to which these special, or consequential, damages may be recovered involves the consideration of many intricate questions of law which would be beyond the scope of this chapter, although the principles already laid down with regard to the recovery of special damages for delay to goods may be taken as generally applicable.

In an action for loss of, or injury to, the luggage of a passenger, or for delay in delivery, the damages will be assessed upon the same principles which apply to goods.

(12.) Railway companies are also liable for the negligence of their servants, resulting in death or personal injury to any person. In the case of death no action was maintainable until the passing, in 1846, of the Act known as Lord Campbell's Act, under which an action can now be brought for the benefit of the parents, grand parents, children, grandchildren or step-children of the deceased person (but not on behalf of any other relative or person), provided the action be brought within twelve months of the death of the deceased. In any such action, actual pecuniary loss must be shown to have been sustained by the persons for whose benefit the action is brought.

In an action for personal injury the plaintiff is entitled to recover, not only the pecuniary loss sustained by him by reason of the accident, such as loss of salary, wages or business profits, and any expenses incurred for medical fees, extra nourishment, nursing, change of air, assistance in business, and the like, but also compensation for bodily pain and suffering. The claim may, furthur, include compensation for losses or expenses to be incurred before the plaintiff may have completely recovered from the effects of the accident, or for any permanent injury which he may have sustained.

CHAPTER XVII.

ON THE RAILWAYS AS A MEANS OF DEFENCE.

IT can hardly be necessary to insist upon the obvious importance of the railway system when considered in relation to the means of warfare, and more particularly in connection with any scheme for the defence of the country in the event of invasion. Thanks to our insular position and to the admirable and powerful navy with which England keeps the narrow seas, it may safely be said that the possibility of an invader ever being able to set foot on our shores, is more or less remote ; but there have not been wanting those of late who have not hesitated to discuss this contingency as one within the regions of practicability, and, whether it be remote or otherwise, it is only prudent to reckon with it.

If a calamity so great should at any time overtake us, it is quite evident that the prospect of our being able to repel the invader and maintain inviolate our hearths and homes would to a very great extent depend upon the perfect equipment and efficient working of the network of railways which now covers these islands. The Government have been fully alive to this fact, and many years ago a step was taken which would probably turn out to be a very prudent one if ever an emergency should arise. A Corps was constituted which is termed the "Engineer and Railway Volunteer Staff Corps," and which is composed of a certain number of engineers, several of the great contractors, and the general managers of most of the principal railways, the contractors forming what is called the "Labour Branch" of the Corps. The intention is that in case of an invasion the officers of this corps would superintend the working of the railways, as they do in time of peace, but acting then under the directions of the military commanders. The railways of the country, so far as might be necessary, and wholly if need be, would have to be, for the time being, given up to the service of the State, as was recently done in Western France, when the experiment was tried of mobilising certain Army Corps, and by thus utilising the means and appliances which are at all times available, and making a free use of the perfect organization and large resources of the great railway companies, it is believed that no difficulty need be anticipated in concentrating a considerable body of troops within a brief period of time upon any part of our shores that might be threatened by a foe.

In the early part of 1885, the War Office instituted a kind of test of the ability of the officers of the Staff Corps to perform this task, which it may be of interest briefly to describe, as although, of course, merely on paper, it served to afford a very fair idea of what could undoubtedly be accomplished by the railway companies in case of need. The test took the form of an "Exercise" proposed by order of the Commander-in-Chief, and constituted in point of fact a kind of problem to which the Staff Corps were required to furnish the solution. The assumption was that an invading force numbering 150,000 men had commenced to disembark on the Coast between Southend and Shoeburyness, and that hostile vessels were simultaneously ascending the Blackwater river to land a strong detachment at Stangate Abbey. Instructions were supposed to have been issued by telegraph for the concentration of six Army Corps, numbering about 130,000 men, on the line of Stanford-le-Hope, Billericay, and Chelmsford, with a view to occupy the Basildon position and repel the invader, three Corps being brought up as rapidly as possible, and the whole within forty-eight hours. Particulars were given as to where the troops were stationed all over the country—North, South, East and West—and the number of men quartered at each place—and in due course the problem was solved and the answer furnished.

It was assumed, of course, that the ordinary traffic would be, for the time being, entirely suspended, that land could be freely encroached upon whenever necessary for the construction of temporary platforms of sleepers and ballast, for loading and unloading horses and artillery, and for other purposes, and that all the railways could be worked as one. Tables were submitted showing in the most complete detail the number of trains required, where each would start from, and the hour of starting, the route travelled, the hour of arrival at destination, the time allowed for refreshments and other purposes on the journey, and the number of men conveyed by each train. The total number of trains employed was 515; the speed was about 25 miles an hour, exclusive of stoppages, the trains following one another on the same lines at intervals of fifteen minutes, and the last train was timed to arrive at Chelmsford within 45 hours and 50 minutes of the hour at which the order was supposed to have been given by telegraph, so that, in theory, at any rate, the defenders were placed in a position to drive the invaders into the sea. Thus it is evident that railways have revolutionised the conditions of modern warfare, much as they have revolutionised everything else that existed before their advent. In the days before the era of railways a kingdom might be lost or won, or the fate of a dynasty decided, before a single army corps could make its way by forced marches from the north of England to the south coast.

Of course, in the event of this country being engaged in warfare on the continent of Europe, or elsewhere abroad, either independently or in conjunction with some other power, the advantages which in a war of defence would be derived from the perfection of our railway system would no longer be available, or if they existed, they might be used against us. For instance, when the Germans invested Paris in the war of 1870-1, not only did they avail themselves of the railways around the city, but they took possession of the extensive locomotive works of the Northern of France Railway, and were thus enabled to repair the rolling stock and plant required to work the railways of which they were in possession, even seeking out and impressing into their service many of the artizans employed in the works, although it must be said to their credit that they honourably paid these men for their labour. Mention of this fact recalls a somewhat amusing incident related to the writer by M. Banderali, the able Locomotive Superintendent of the Northern of France Railway, and which was a striking proof of the extent to which the courtesies of nations are sometimes displayed in modern warfare. M. Banderali occupied a comfortable and well-furnished residence at St. Denis, and when, on the approach of the

German army, he was forced to retreat with the Northern army to Lisle, taking with him, as far as possible, the rolling stock and other *personnel* of the railway, he had no time to dismantle his house, or remove any of his goods and chattels. He accordingly left behind him a letter addressed to any officers of the German army who might be quartered in his house, politely begging them to make free use of everything they found there, but expressing a hope that they would do as little damage as possible. But the Teuton was not to be beaten in courtesy by the Gaul, for on M. Banderali's return, after the evacuation, he found everything just as he had left it, and upon the piano in his drawing-room was a volume of Schubert's songs subscribed to their courteous, though involuntary, host by the officers of the German army who had been his guests!

Colonel H. M. Hozier, who recently read a paper before the members of the Royal United Service Institution on the "Equipment and Transport of Modern Armies," enlarged upon the importance, to military commanders, of having the control of an efficient railway corps able to move with an army, to construct or repair railways in advancing, and to dismantle and break them down when necessary to cover a retreat. There is no doubt that in such a case, it would be of the greatest assistance to those who were conducting such operations, to be able to command the services not only of trained Engineer officers, but of artificers, engine drivers, firemen, and men of all the various crafts connected with the making, repairing, and working of railways; and it is satisfactory to add that the need of such a body of men has not been lost sight of by the

War Office, and that the nucleus of a force of the kind has already been formed. At the locomotive works of the London and North Western Company at Crewe, where something like 6,000 men are employed, a Volunteer force was embodied in the early part of the year 1887, under the title of the 2nd Cheshire (Railway) Engineer Volunteers, which comprises at present—and while it is as yet perhaps only in its infancy—an effective force of 631 men, of whom 23 are officers, 578 are non-commissioned officers and men, and 30 are first-class Army Reserve men who are employed in the works, and are attached to the corps as supernumeraries. This corps is composed almost entirely of men who, in their ordinary avocations, are smiths, fitters, firemen, etc., and they are undergoing, in addition to the ordinary infantry drill, a course of instruction in military engineering. The corps, having been incorporated upon the ordinary volunteer principle, is at present only liable to be called out in case of invasion, but such men as these would be invaluable in case of a war on the continent, or elsewhere, in which we might be engaged, and the War Office, recognising this fact, have arranged that a certain proportion of the men comprising each company should enlist in the Royal Engineers, as a matter of form, for one day, and then be placed in the first-class Army Reserve for six years, in which case they would receive pay, and their services would be available in case of need either at home or abroad. A considerable number of men have already come forward, and if the movement proves successful, the example will doubtless be followed in other large railway works throughout the country.

The Crewe Volunteers were reviewed by H.R.H. the

Duke of Cambridge, on the occasion of his opening the Crewe Park, on the 9th June, 1888, when he complimented them very highly on their efficiency, and spoke of their probable value to the country in the event of war; at the same time expressing the hope that the example so well set at Crewe would be followed elsewhere.

NOTE TO SECOND EDITION.

"The officers of the Staff Corps, under the direction of the War Office, are at present engaged in drawing up a carefully considered code of Rules and Regulations for the working of the railways of Great Britain in time of war or mobilisation, and also for the conduct of transport operations in connection with railways abroad, in the event of this country being engaged in a foreign war."

APPENDIX.

A writer in the *Edinburgh Review*, of July, 1889, commenting on Mr. Acworth's recently published work on "The Railways of England," is apparently much impressed with the difficulties which must arise, and the loss of profit which must ensue, from the fact of traffic of various descriptions, and travelling at different rates of speed, having to be accommodated on the same railway, and he puts forward the theory, that in cases where a railway is doubled, that is, where there are two up and two down main lines, if one of each were appropriated to the express passenger trains, running at forty-five to sixty miles an hour, and the others devoted to such selected merchandise traffic as would pay for a speed of about thirty miles an hour, and to passenger trains calling at every station, leaving the heavy mineral and low-priced goods traffic to be accommodated by the canals, the railways would thus be utilised in the most remunerative manner, and there would be a lucrative future in store for the railway shareholder.

This proposition is one based upon fallacies which are sufficiently apparent to any one practically conversant with the working of railways. The reviewer, in short, advises the railway companies to increase their revenue by cutting off one of the most important branches of their business—and that not the least lucrative—on the assumption that the others would in the end grow to such an extent as to absorb the whole of the accommodation provided; but it is very doubtful whether there are sufficient grounds for this initial assumption, since in a country of small extent, like Great Britain, there must be limits to the possibilities of expansion of any class of traffic. In the second place, he is apparently not aware that the policy of appropriating one track to the express passenger trains, and the other to the goods and slow passenger trains, is one already adopted on sections where there are four lines of rails ; besides which, he overlooks the fact that the goods traffic is practically worked during the night, when there are very few passenger trains running. Thirdly, when he relegates the heavy goods and mineral traffic to the canals, he forgets to inquire how far these latter would be competent to provide for it. Canals only exist in certain districts, and they cannot be taken to the doors of the manufacturers, as railways are, by means of branch-lines and sidings throughout the country ; and the idea, for example, of the canals accomplishing the gigantic task of bringing into London its daily coal supply of about 32,000 tons, and distributing it throughout the metropolis in the manner expected of the railway companies, is one which, to any one familiar with the subject, appears almost grotesque, to say nothing of the fact that if the railway companies abandoned this class of business, the millions of money which have been spent in providing for it would be practically thrown away.

The reviewer, too, is mistaken in hastily assuming, as he appears to do, that passenger traffic is remunerative to railway companies in a high degree, while goods traffic, especially of the heavier classes, is carried with a small margin of profit. A very few simple calculations drawn from the published accounts and other known statistics of the London and North Western Railway will serve to correct this error.

In the year 1888 that Company received for the conveyance of passenger train traffic, £4,251,329 ; the working expenses amounted to £2,268,157, leaving £1,983,172, or 46⅔ per cent. as representing the net profit. During the same year the same Company received for the conveyance of goods and mineral traffic, £6,198,583, and the expenses of working it amounted to £3,237,154 ; the net profit being £2,961,429, or 47¾ per cent. ; so that the percentage of profit upon merchandise traffic, taken as a whole, is more than 1 per cent. greater than that upon passenger traffic. It may be added that of the total of 35,922,619 tons of merchandise traffic carried upon the London and North Western Railway during the period mentioned, no less than 27,898,314, or about 77⅔ per cent. consisted of coal, coke, and the other low-priced mineral traffic, which the reviewer so much despises. It is impossible accurately to calculate the actual rate of working expenses upon each particular class of traffic, but it seems tolerably clear that, if nearly 78 per cent. of the whole were carried at a loss, and were, as the reviewer puts it, "A robbery of the shareholders," there would have to be a rate of profit upon the remaining 22 per cent. which we know is far from existing, in order to achieve the general result described above. It is quite true, of course, that coal, and the other mineral and heavy traffic, is carried at a much lower rate per ton than the lighter and more valuable descriptions of merchandise; but it must be borne in mind that the service of conveying it involves nothing more than the mere cost of haulage, and the provision of sidings, to receive and marshal the waggons, the vehicle being provided, and all loading and unloading services performed by the senders and consignees, in most cases, within their own premises. On the other hand, for the ordinary merchandise, it is necessary to provide expensive warehouses and sheds, costly machinery and appliances, waggons and sheets, and an army of men to perform the handling services, to say nothing of the greater risk; so that, on the whole, it may be conclusively assumed that one class of traffic pays as well as another.

INDEX.

WILLIAM RIDER AND SON, PRINTERS. LONDON.

2, WHITE HART STREET,
PATERNOSTER SQUARE, E.C.

WHITTAKER & CO.'S

LIST OF

Classical, Educational, and Technical Works.

CONTENTS.

July, 1889.

Mr. Leland's Educational Publications.

Third Edition, Crown 8vo, Cloth, 6s.

PRACTICAL EDUCATION.

A WORK ON

PREPARING THE MEMORY, DEVELOPING QUICKNESS OF PERCEPTION, AND TRAINING THE CONSTRUCTIVE FACULTIES.

BY CHARLES G. LELAND.

Author of " The Minor Arts," " Twelve Manuals of Art Work," " The Album of Repoussé Work," Industrial Art in Education, or Circular No. 4, 1882," " Hints on Self-Education," etc.

MR. LELAND was the first person to introduce *Industrial Art* as a branch of education in the public schools of America. The Bureau of Education at Washington, observing the success of his work, employed him in 1862 to write a pamphlet showing how hand-work could be taken or taught in schools and families. It is usual to issue only 15,000 of these pamphlets, but so great was the demand for this that in two years after its issue more than 60,000 were given to applicants. This work will be found greatly enlarged in "Practical Education." Owing to it thousands of schools, classes, or clubs of industrial art were established in England, America and Austria. As at present a great demand exists for information as to organizing Technical Education, this forms the first part of the work. In it the author indicates that all the confusion and difference of opinion which at present prevails as to this subject, may very easily be obviated by simply beginning by teaching the youngest the easiest arts of which they are capable, and by thence gradually leading them on to more advanced work.

"The basis of Mr. Leland's theory," says a reviewer, "is that before learning, children should acquire the art of learning. It is not enough to fill the memory, memory must first be created. By training children to merely memorize, extraordinary power in this respect is to be attained in a few months. With this is associated exercises in quickness of perception, which are at first purely mechanical, and range from merely training the eye to mental arithmetic, and problems in all branches of education. Memory and quickness of perception blend in the development of the constructive faculties or hand-work. Attention or interest is the final factor in this system."

"*Mr. Leland's book will have a wide circulation. It deals with the whole subject in such a downright practical fashion, and is so much the result of long personal experience and observation, as to render it a veritable mine of valuable suggestions.*"—BRITISH ARCHITECT.

"*It has little of the dryness usually associated with such books; and no teacher can read its thoughtful pages without imbibing many valuable ideas.*"—SCOTTISH EDUCATIONAL NEWS.

"*Strongly to be recommended.*"—CHEMICAL NEWS.

"*This valuable little work.*"—LIVERPOOL DAILY POST.

"*Many of Mr. Leland's suggestions might be carried out advantageously among the young folks in our large towns and villages.*"—NORTHERN WHIG.

Minor Arts and Industries.

A SERIES OF ILLUSTRATED AND PRACTICAL MANUALS FOR SCHOOL USE AND SELF-INSTRUCTION.

EDITED BY CHARLES G. LELAND.

This series of manuals on "The Minor Arts and Industries" is designed on the lines laid down in Mr. Leland's treatise on education. Each handbook will present the subject with which it deals in a thoroughly popular and practical manner; the lessons carry the student on his road step by step from the veriest elements to the point where the most advanced works fitly find their place in his course of study; in short, the greatest pains are taken to ensure a thorough mastery of the rudiments of each subject, and to so clearly state eacb lesson, illustrating it where necessary by plans and drawings, that even very young children may be interested in and trained to practical work. On similar grounds the self-taught student will find these manuals an invaluable aid to his studies.

Part 1 *now ready, Paper cover,* 1*s. or in cloth,* 1*s.* 6*d.*

DRAWING AND DESIGNING:

IN A SERIES OF LESSONS,

WITH NUMEROUS ILLUSTRATIONS,

BY CHARLES G. LELAND, M.A., F.R.L.S.

Other volumes will follow at intervals, amongst the subjects of which may be named—

WOOD CARVING.	METAL WORK.
MODELLING.	CARPENTERING.
LEATHER WORK.	COMMERCE, ETC.

GREEK AND LATIN.

Bibliotheca Classica.

A Series of Greek and Latin Authors, with English Notes, edited by eminent Scholars. 8vo.

ÆSCHYLUS. By F. A. Paley, M.A. 8*s.*

CICERO'S ORATIONS. By G. Long, M.A. 4 vols. 8*s.* each.

DEMOSTHENES. By R. Whiston, M.A. 2 vols. 8*s.* each.

EURIPIDES. By F. A. Paley, M.A. 3 vols. 8*s.* each.

HERODOTUS. By Rev. J. W. Blakesley, B.D. 2 vols. 12*s.*

HESIOD. By F. A. Paley, M.A. 5*s.*

HOMER. By F. A. Paley, M.A. Vol. I. 8*s.* Vol. II. 6*s.*

HORACE. By Rev. A. J. Macleane, M.A. 8*s.*

JUVENAL AND PERSIUS. By Rev. A. J. Macleane, M.A. 6*s.*

LUCAN. The Pharsalia. By C. E. Haskins, M.A., and W. E. Heitland, M.A. 14*s.*

PLATO. By W. H. Thompson, D.D. 2 vols. 5*s.* each.

SOPHOCLES. Vol. I. By Rev. F. H. Blaydes, M.A. 8*s.*

——— Vol. II. Philoctetes—Electra—Ajax and Trachiniæ. By F. A. Paley, M.A. 6*s.*

TACITUS: The Annals. By the Rev. P. Frost. 8*s.*

TERENCE. By E. St. J. Parry, M.A. 9*s.*

VIRGIL. By J. Conington, M.A. 3 vols. 10*s.* 6*d.* each.

*** In some cases the volumes cannot be sold separately. The few copies that remain are reserved for complete sets, which may be obtained, at present, for 9*l.*

Grammar School Classics.

A Series of Greek and Latin Authors, with English Notes. Fcap. 8vo.

CÆSAR: DE BELLO GALLICO. By George Long, M.A. 4*s.*

——— Books I.-III. For Junior Classes. By George Long, M.A. 1*s.* 6*d.*

——— Books IV. and V. in 1 vol. 1*s.* 6*d.*

——— Books VI. and VII. in 1 vol. 1*s.* 6*d.*

CATULLUS, TIBULLUS, AND PROPERTIUS. Selected Poems. With Life. By Rev. A. H. Wratislaw. 2*s.* 6*d.*

CICERO: DE SENECTUTE, DE AMICITIA, and SELECT EPISTLES. By George Long, M.A. 3*s.*

CORNELIUS NEPOS. By Rev. J. F. Macmichael. 2*s.*

HOMER: ILIAD. Books I.-XII. By F. A. Paley, M.A. 4*s.* 6*d.*
Books I.-VI., 2*s.* 6*d.*; Books VII.-XII., 2*s.* 6*d.*

HORACE. With Life. By A. J. Macleane, M.A. 3*s.* 6*d.* In 2 Parts: Odes, 2*s.*; Satires and Epistles, 2*s.*

JUVENAL: SIXTEEN SATIRES. By H. Prior, M.A. 3*s.* 6*d.*

MARTIAL: SELECT EPIGRAMS. With Life. By F. A. Paley, M.A. 4*s.* 6*d.*

OVID: The FASTI. By F. A. Paley, M.A. 3*s.* 6*d.*

——— Books I. and II. in 1 vol. 1*s.* 6*d.*

——— Books III. and IV. in 1 vol. 1*s.* 6*d.*

——— Books V. and VI. in 1 vol. 1*s.* 6*d.*

SALLUST: CATILINA and JUGURTHA. With Life. By G. Long, M.A., and J. G. Frazer. 3*s.* 6*d.* Catilina, 2*s.* Jugurtha, 2*s.*

TACITUS: GERMANIA and AGRICOLA. By Rev. P. Frost. 2*s.* 6*d.*

VIRGIL: BUCOLICS, GEORGICS, and ÆNEID, Books I.-IV. Abridged from Professor Conington's edition. 4*s*. 6*d*.

——— ÆNEID, Books V.-XII. 4*s*. 6*d*.

Also in 9 separate volumes, 1*s*. 6*d*. *each*.

XENOPHON: The ANABASIS. With Life. By Rev. J. F. Macmichael. 3*s*. 6*d*.

Also in 4 separate volumes, 1*s*. 6*d*. *each*.

——— The CYROPÆDIA. By G. M. Gorham, M.A. 3*s*. 6*d*.

——— Books I. and II. in 1 vol. 1*s*. 6*d*.

——— Books V. and VI. in 1 vol. 1*s*. 6*d*.

——— MEMORABILIA. By Percival Frost, M.A. 3*s*.

A GRAMMAR-SCHOOL ATLAS OF CLASSICAL GEOGRAPHY, containing Ten selected Maps. Imperial 8vo. 3*s*.

Uniform with the Series.

THE NEW TESTAMENT, in Greek. With English Notes, &c. By Rev. J. F. Macmichael. 4*s*. 6*d*. Separate parts, St. Matthew, St. Mark, St. Luke, St. John, Acts, 6*d*. each, sewed.

Lower Form Series.

With Notes and Vocabularies.

ECLOGÆ LATINÆ; OR, FIRST LATIN READING-BOOK, WITH ENGLISH NOTES AND A DICTIONARY. By the late Rev. P. Frost, M.A. New Edition. Fcap. 8vo. 1*s*. 6*d*.

LATIN VOCABULARIES FOR REPETITION. By A. M. M. Stedman, M.A. 2nd Edition, revised. Fcap. 8vo. 1*s*. 6*d*.

EASY LATIN PASSAGES FOR UNSEEN TRANSLATION. By A. M. M. Stedman, M.A. Fcap. 8vo. 1*s*. 6*d*.

VIRGIL'S ÆNEID. Book I. Abridged from Conington's Edition by Rev. J. G. Sheppard, D.C.L. With Vocabulary by W. F. R. Shilleto. 1*s.* 6*d.* [*Now ready.*

CÆSAR: DE BELLO GALLICO. Book I. With Notes by George Long, M.A., and Vocabulary by W. F. R. Shilleto. 1*s.* 6*d.* [Book II. *in the press.*

TALES FOR LATIN PROSE COMPOSITION. With Notes and Vocabulary. By G. H. Wells, M.A. 2*s.*

MATERIALS FOR LATIN PROSE COMPOSITION. By the late Rev. P. Frost, M.A. New Edition. Fcap. 8vo. 2*s.* Key (for Tutors only), 4*s.*

A LATIN VERSE-BOOK. AN INTRODUCTORY WORK ON HEXAMETERS AND PENTAMETERS. By the late Rev. P. Frost, M.A. New Edition. Fcap. 8vo. 2*s.* Key (for Tutors only), 5*s.*

ANALECTA GRÆCA MINORA, with INTRODUCTORY SENTENCES, ENGLISH NOTES, AND A DICTIONARY. By the late Rev. P. Frost, M.A. New Edition. Fcap. 8vo. 2*s.*

GREEK TESTAMENT SELECTIONS. By A. M. M. Stedman, M.A. 2nd Edition, enlarged, with Notes and Vocabulary. Fcap. 8vo. 2*s.* 6*d.*

Cambridge Texts with Notes.

A Selection of the most usually read of the Greek and Latin Authors, Annotated for Schools. Fcap. 8vo, 1*s.* 6*d. each, with exceptions.*

EURIPIDES. ALCESTIS — MEDEA — HIPPOLYTUS—HECUBA—BACCHÆ—ION (2*s.*)—ORESTES—PHOENISSÆ—TROADES—HERCULES FURENS—ANDROMACHE — IPHIGENIA IN TAURIS—SUPPLICES. By F. A. Paley, M.A., LL.D.

ÆSCHYLUS. PROMETHEUS VINCTUS—SEPTEM CONTRA THEBAS—AGAMEMNON—PERSÆ—EUMENIDES—CHŒPHORŒ. By F. A. Paley, M.A., LL.D.

SOPHOCLES. ŒDIPUS TYRANNUS—ŒDIPUS COLONEUS—ANTIGONE—ELECTRA—AJAX. By F. A. Paley, M.A., LL.D.

THUCYDIDES. BOOK IV. By. F. A. Paley, M.A., LL.D.

XENOPHON. HELLENICA. BOOK II. By Rev. L. D. Dowdall, M.A.

——— ANABASIS. Edited by Rev. J. F. Macmichael. *New edition*, revised by J. E. Melhuish, M.A. In 6 vols. Book I. (with Life, Introduction, Itinerary, &c.); Books II. and III. 2*s*.; Book IV., Book V., Book VI., Book VII.

HOMER. ILIAD. BOOK I. By F. A. Paley, M.A., LL.D. 1*s*.

VIRGIL (abridged from Conington's edition). BUCOLICS: GEORGICS, 2 parts: ÆNEID, 9 parts.

TERENCE. ANDRIA—HAUTON TIMORUMENOS—PHORMIO—ADELPHOE. By Professor Wagner, Ph.D.

CICERO. DE SENECTUTE—DE AMICITIA—EPISTOLÆ SELECTÆ. By G. Long, M.A.

OVID. SELECTIONS. By A. J. Macleane, M.A.

Others in preparation.

Cambridge Greek and Latin Texts.

These Texts, which are clearly printed at the Cambridge University Press, on good paper, and bound in a handy form, have been reduced in price, and will now meet the requirements of masters who wish to use Text and Notes separately.

ÆSCHYLUS. By F. A. Paley, M.A. 2*s*.

CÆSAR: DE BELLO GALLICO. By G. Long, M.A. 1*s*. 6*d*.

CICERO: DE SENECTUTE et DE AMICITIA, et EPISTOLÆ SELECTÆ. By G. Long, M.A. 1*s*. 6*d*.

CICERONIS ORATIONES. Vol. I. (in Verrem.) By G. Long, M.A. 2*s.* 6*d.*

EURIPIDES. By F. A. Paley, M.A. 3 vols., each 2*s.*

——— Vol. I. Rhesus—Medea—Hippolytus—Alcestis—Heraclidæ—Supplices—Troades—Index.

——— Vol. II. Ion—Helena—Andromache—Electra—Bacchæ—Hecuba—Index.

——— Vol. III. Hercules Furens—Phœnissæ—Orestes—Iphigenia in Tauris—Iphigenia in Aulide—Cyclops—Index.

HERODOTUS. By J. G. Blakesley, B.D. 2 vols., each 2*s.* 6*d.*

HOMERI ILIAS. I.-XII. By F. A. Paley, M.A. 1*s.* 6*d.*

HORATIUS. By A. J. Macleane, M.A. 1*s.* 6*d.*

JUVENAL ET PERSIUS. By A. J. Macleane, M.A. 1*s.* 6*d.*

LUCRETIUS. By H. A. J. Munro, M.A. 2*s.*

SALLUSTI CRISPI CATILINA ET JUGURTHA. By G. Long, M.A. 1*s.* 6*d.*

SOPHOCLES. By F. A. Paley, M.A. 2*s.* 6*d.*

TERENTI COMŒDIÆ. By W. Wagner, Ph.D. 2*s.*

THUCYDIDES. By J. G. Donaldson, D.D. 2 vols., each 2*s.*

VERGILIUS. By J. Conington, M.A. 2*s.*

XENOPHONTIS EXPEDITIO CYRI. By J. F. Macmichael, B.A. 1*s.* 6*d.*

NOVUM TESTAMENTUM GRÆCE. By F. H. Scrivener, M.A. 4*s.* 6*d.* An edition with wide margin for notes, half bound, 12*s.*

Annotated Editions.

CICERO'S MINOR WORKS. De Officiis, &c. &c. With English Notes, by W. C. Tylor, LL.D. 12mo. cloth, 3*s*. 6*d*.

VIRGIL'S ÆNEID. With English Notes, by C. Anthon, LL.D. Adapted for use in English Schools by the Rev. F. Metcalfe, M.A. *New Edition*. 12mo. 7*s*. 6*d*.

Greek Class Books.

BEATSON'S PROGRESSIVE EXERCISES ON THE COMPOSITION OF GREEK IAMBIC VERSE. 12mo. cloth, 3*s*.

DAWSON'S GREEK-ENGLISH LEXICON TO THE NEW TESTAMENT. *New Edition*, by Dr. Tylor. 8vo. cloth, 9*s*.

NOVUM TESTAMENTUM GRÆCE. Textus Stephanici, 1550. Accedunt variæ Lectiones editionum Bezæ, Elzeviri, Lachmanni, Tischendorfii, Tregellesii, curante F. H. Scrivener, M.A. 4*s*. 6*d*. An Edition with wide margin for MS. Notes, 4to. half-bound morocco, 12*s*.

——— Textûs Stephanici, A.D. 1550, Cum variis Lectionibus Editionum Bezæ, Elzeviri, Lachmanni, Tischendorfii, Tregellesii, Westcott-Hortii, Versionis Anglicanæ Emendatorum, Curante F. H. A. Scrivener, A.M., D.C.L., LL.D., Accedunt Parallela S. Scripturæ Loca. Small post 8vo. cloth, pp. xvi.-598, 7*s*. 6*d*.

EDITIO MAJOR *containing, in addition to the matter in the other Edition, the Capitula* (*majora et minora*) *and the Eusebian Canons, the various Readings of Westcott and Hort, and those adopted by the Revisers; also a revised and much-enlarged series of References.*

——— VALPY'S. For the use of Schools. 12mo. cloth, 5*s*.

——— Edited by Rev. Macmichael. *See Grammar School Classics.*

Students' Editions of the Gospels and the Acts.

Crown 8vo. cloth.

THE GOSPEL OF S. MATTHEW. The Greek Text, with Critical, Grammatical, and Explanatory Notes, &c., by the late Rev. W. Trollope, M.A., re-edited by the Rev. W. H. Rowlandson, M.A. 5*s*.

GOSPEL OF S. MARK. The Greek Text, with Critical, Grammatical, and Explanatory Notes, Prolegomena, &c., by Rev. W. H. Rowlandson, M.A. 4*s*. 6*d*.

GOSPEL OF S. LUKE. The Greek Text, with Critical, Grammatical, and Explanatory Notes, &c., by the late Rev. W. Trollope, M.A., revised and re-edited by the Rev. W. H. Rowlandson, M.A. 5*s*.

ACTS OF THE APOSTLES. The Greek Text, with Critical, Grammatical, and Explanatory Notes, and Examination Questions, by Rev. W. Trollope, M.A., re-edited and revised by the Rev. G. F. Browne, M.A. 5*s*.

Latin Class Books.

BEDFORD'S PROPRIA QUÆ MARIBUS; or, Short Rules for the Genders of Latin Nouns, and a Latin Prosody. 12mo. 1*s*.

BOSSUT'S LATIN WORD BOOK; or, First Step to the Latin Language. 18mo. 1*s*.

——— LATIN PHRASE BOOK. 18mo. 1*s*.

FLORILEGIUM POETICUM. A Selection of Elegiac Extracts from Ovid and Tibullus. *New edition*, greatly enlarged with English Notes. By the late Rev. P. Frost, M.A. Fcap. 8vo. 2*s*.

GRADUS AD PARNASSUM; sive novus sinonymorum, epithetorum, versuum, ac phrasium poeticarum, thesaurus. *New edition.* By G. Pyper. 12mo. cloth, 7*s*.

——— BY VALPY. Whittaker's Improved edition. Latin and English. *New edition.* Royal 12mo. 7*s*. 6*d*.

STODDART'S NEW DELECTUS; or, Easy Steps to Latin Construing. For the use of Pupils commencing the Language. Adapted to the best Latin Grammars, with a Dictionary attached. *New edition.* 12mo. 4*s.*

PENROSE'S (REV. JOHN) Easy Exercises in Latin Elegiac Verse. *New edition.* 12mo. cloth, 2*s.*

——— Key to ditto, for Tutors only, 3*s.* 6*d.*

Atlases.

LONG'S ATLAS OF CLASSICAL GEOGRAPHY. Containing Twenty-four Maps. Constructed by William Hughes, F.R.G.S., and Edited by George Long, M.A. *New edition,* with Coloured Outlines, and an Index of Places. Royal 8vo. 6*s.*

LONG'S GRAMMAR SCHOOL ATLAS OF CLASSICAL GEOGRAPHY. Containing Ten Maps, selected from the larger Atlas. Constructed by W. Hughes, F.R.G.S., and edited by George Long, M.A. *New edition,* with Coloured Outlines. Royal 8vo. 3*s.*

English Language and Miscellaneous.

ALLEN AND CORNWELL'S SCHOOL GRAMMAR. Cloth, 1*s.* 9*d.*

——— GRAMMAR FOR BEGINNERS. Cloth, 1*s.*

BELL'S MODERN READER AND SPEAKER. A Selection of Poetry and Prose, from the Writings of Eminent Authors. 12mo. 3*s.* 6*d.*

DUNCAN'S ENGLISH EXPOSITOR; or, Explanatory Spelling-book. Containing an Alphabetical Collection of all the most useful, proper, and elegant words in the English language, divided into Syllables, and properly accented. *New edition.* 12mo. 1*s.* 6*d.*

LATHAM'S (R. G.) DICTIONARY OF THE ENGLISH LANGUAGE. Abridged and condensed into one volume. 8vo. cloth, 14*s.*

MACKAY (C.) A DICTIONARY OF LOWLAND SCOTCH. By Charles Mackay, LL.D. With an Introductory Chapter on the Poetry, Humour, and Literary History of the Scottish Language, and an Appendix of Scottish Proverbs. Large post 8vo. cloth, 7*s*. 6*d*. half bound, 8*s*. 6*d*.

——— SELECTED POEMS AND SONGS OF CHARLES MACKAY, LL.D. With a Commendatory and Critical Introduction by Eminent Writers. Wide foolscap 8vo. half cloth boards, 1*s*. 6*d*. Sewed, 1*s*.

WEBSTER'S DICTIONARY OF THE ENGLISH LANGUAGE. Including Scientific, Technical, and Biblical Words and Terms. *New edition*, with Supplement of over 4,600 New Words and Meanings. 4to. cloth, 1*l*. 1*s*.; half-calf, 1*l*. 10*s*. With Appendices, £1 11*s*. 6*d*.; half-calf, 2*l*.

SHAKESPEARE'S PLAYS, with Text and Introduction in English and German. Edited by C. Sachs, Prof. Ph. D. 8vo. cloth, each Play or Number, 10*d*.

Now Ready:

1. Julius Cæsar.
2. Romeo and Juliet.
3. King Henry VIII.
4. King Lear.
5. Othello.
6. Hamlet.
7. A Midsummer Night's Dream.
8. Macbeth.
9. King John.
10. King Richard II.
11. King Henry IV. I.
12. ,, ,, II.
13. King Henry V.
14. King Richard III.
15. Cymbeline.
16. Coriolanus.
17. Antony and Cleopatra.
18. Merchant of Venice.
19. Much Ado about Nothing.

Others to follow.

"This edition will be quite a godsend to grown-up students of either language, for the ordinary class reading books are too childish to arrest their attention. The parallel paging saves the labour of using a dictionary, and the series is so low in price as to place it within the reach of all."
Saturday Review.

SHAKESPEARE REPRINTS. 1. King Lear. Parallel Texts of Quarto 1 and Folio 1. Edited by Dr. W. Vietor, of Marburg. Square 16mo. cloth, 3*s*. 6*d*.

The texts of the first quarto and folio, with collations from the later quartos and folios, are here printed in a compact and convenient volume, intended as a class-book in the University.

Miscellaneous Educational Books.

SEIDEL (ROBT.) INDUSTRIAL EDUCATION: A Pedagogic and Social Necessity. Crown 8vo. 4*s*.

WOODWARD (C.M.) THE MANUAL TRAINING SCHOOL, ITS AIMS, METHODS, AND RESULTS. With Figured Drawings of Shop Exercises in Woods and Metals. 8vo. 10*s*.

BIBLIOGRAPHY OF EDUCATION. Hints toward a Select and Descriptive Bibliography of Education. Arranged by Topics, and Indexed by Authors. By G. Stanley Hall, Professor, John Hopkins University, and John M. Mansfield. Post 8vo. cloth, pp. xvi.-309, 7*s*. 6*d*.

CHEPMELL'S (REV. DR.) SHORT COURSE OF GRECIAN, ROMAN, AND ENGLISH HISTORY. *New edition.* 12mo. 5*s*. Questions on, 12mo. 1*s*.

COLTON (B. P.) ELEMENTARY COURSE OF PRACTICAL ZOOLOGY. By B. P. Colton, A.M., Instructor in Biology, Ottawa High School. Crown 8vo. cloth, pp. xiv.-182, 4*s*. 6*d*.

CORNWELL'S SCHOOL GEOGRAPHY. 3*s*. 6*d*. With Thirty Maps on Steel, 5*s*. 6*d*.

—— GEOGRAPHY FOR BEGINNERS. 1*s*. With Questions, 1*s*. 4*d*.

DURHAM UNIVERSITY CALENDAR, with Almanack. Cloth, 1*s*. 6*d*. [*Published annually.*

JOYCE (P. W.) A HANDBOOK OF SCHOOL MANAGEMENT AND METHODS OF TEACHING. By P. W. Joyce, LL.D., &c. 11*th edition, revised.* Cloth, 3*s*. 6*d*.

NATURE READERS. Seaside and Wayside. No. 1. By Julia McNair Wright. Cloth, 1*s*. 6*d*.

The first of a Series of Primary Readers for young children. It treats of crabs, wasps, spiders, bees, and some univalve molluscs.

PINNOCK'S HISTORY OF ENGLAND. From the Invasion of Julius Cæsar. With a Biographical and Historical Dictionary. Questions for Examination, Genealogical Tables, Progress of Literature and the Constitution, &c. Illusted. Continued by the Rev. W. H. Pinnock, LL.D. *New edition.* 12mo. 6*s.*

—— HISTORY OF GREECE. With an Introduction on the Natural and Political Geography of Greece, Dictionary of Difficult Terms, Questions for Examination, Genealogical Tables, &c. Illustrated. By Dr. W. C. Taylor. *New edition.* 12mo. 5*s.* 6*d.*

—— HISTORY OF ROME. With an Introduction, the Geography of the Roman Empire, Notices of the Roman Manners, and Illustrations, Questions for Examination, Chronological Index, &c. Illustrated. By Dr. W. C. Taylor. *New edition.* 12mo. 5*s.* 6*d.*

PINNOCK'S CATECHISMS OF THE ARTS, SCIENCES, AND LITERATURE. Whittaker's Improved Editions. Illustrated with Maps, Plates, and Woodcuts, carefully re-edited. 18mo. price 9*d.* each.

HISTORY.—Modern—Ancient—Universal—Bible and Gospel—Scripture—Chronology—England—Scotland—France—America—Rome—Greece—Jews.

GEOGRAPHY.—Ancient—Modern, Improved Edition—Modern, Original Edition—Sacred—England and Wales—Use of the Globes.

GRAMMAR.—English—French—German—Italian—Latin—Spanish—Greek: Part I. Accidence. Part II. Syntax and Prosody—Hebrew.

MATHEMATICS, &c.—Algebra (two Parts)—Arithmetic—Geometry—Navigation—Land Surveying.

RELIGION.—Religion—Natural Theology—Scripture History—Bible and Gospel History.

FINE ARTS, &c.—Architecture—Drawing—Perspective—Music—Singing.

LITERATURE.—Mythology—Rhetoric—Logic—British Biography—Classical Biography.

MISCELLANEOUS.—First Catechism—General Knowledge—Intellectual Philosophy—Agriculture—English Law—Heraldry—Medicine—Moral and Social Duties—Trade and Commerce.

SCHLEYER'S GRAMMAR, with Vocabularies of Volapuk (the Language of the World), for all Speakers of the English Language. Second (greatly Revised) Edition. By W. A. Seret, Certificated Teacher of the Universal Language. Crown 8vo. pp. 420, sewed, 5*s*. 6*d*.; cloth, 6*s*. 6*d*.

SHUMWAY (E. S.) A DAY IN ANCIENT ROME. With numerous Illustrations. By Edgar S. Shumway, Professor, Rutger's College, New Brunswick. Small 4to. cloth, 5*s*.

WATTON'S ORIGINAL AIDS TO EDUCATION.

Hand-series of Tablets, in Stiff Covers, 3*d*. each.

Leading Events of General History.
Chief Events of Old Testament History.
Chief Events of New Testament History.
Prophecies and other Scripture Subjects.
Chief Events of Grecian History.
Chief Events of Roman History.
Chief Events of Eastern Empire.
Chief Events of German History.
Chief Events of English History.
Chief English Battles and Results.
Chief Events of Scottish History.
Chief Events of French History.
Chief Events of Prussian History.
Chief Events of Russian History.
Eminent Men of Modern Times.
Chief Events of Church History.
Natural System of Botany.
The Linnæan System of Botany.
Natural History—Zoology.
Natural Philosophy.
Principles of Grammatical Analysis, with Examples.
Guide to English Parsing, with Examples.
Abstract of Heathen Mythology.
Word Formation—Saxon, Latin, and Greek Prefixes, with Examples.
Chief Grecian and Roman Battles and Results.

LARGE TYPE SERIES OF TABLETS

(20 by 23 inches), embracing Historical, Geographical, and other Subjects, 4*d*. each, for suspension.

WATTON'S SKELETON EXERCISE BOOKS.

For History, Geography, Biography, Analysis, Parsing, and Chronology, with Script Headings and Specimen Page. Price regulated by the thickness of the books, 1*s*. and 2*s*. each.
Also now ready, a filled Biographical Exercise Book, 2 Series, each 1*s*.
Charts systematically arranged with date words, 60 pages, cloth, 1*s*. Selected Descriptive Poetry, 1*s*.
Object Lessons, Nos. 1, 2, 3, and 4, 32 pp., in stiff covers, 2*d*. each.

School and University Analyses.

By the Rev. Dr. Pinnock.

AN ANALYSIS OF SCRIPTURE HISTORY; Intended for Readers of Old Testament History, and the University Examinations; with Maps, Copious Index, and Examination Questions. 18mo. cloth, 3*s.* 6*d.*

AN ANALYSIS OF NEW TESTAMENT HISTORY; Embracing the Criticism and Interpretation of the original Text; with Questions for Examination. 18mo. cloth, 4*s.*

AN ANALYSIS OF ECCLESIASTICAL HISTORY; From the Birth of Christ, to the Council of Nice, A.D. 325. With Examination Questions. 18mo. cloth, 3*s.* 6*d.*

ANALYSIS OF ENGLISH CHURCH HISTORY; comprising the Reformation period, and subsequent events; with Questions of Examination, especially intended for the Universities and Divinity Students in general. 18mo. cloth, 4*s.* 6*d.*

A SHORT ANALYSIS OF OLD TESTAMENT HISTORY. With Questions for Schools. 18mo. cloth, 1*s.* 6*d.*

A SHORT ANALYSIS OF NEW TESTAMENT HISTORY. With Questions for Schools. 18mo. cloth, 1*s.* 6*d.*

Arithmetic and Euclid.

PINNOCK'S ARITHMETICAL TABLES OF MONEY, WEIGHTS, AND MEASURES. With Questions for Examination, and Explanatory Notes, &c. 18mo. 3*d.*

——— FIRST CIPHERING BOOK. Containing Easy Exercises in the First Rules of Arithmetic. 4to. sewed, 1*s.*

RYAN'S CIVIL SERVICE ARITHMETICAL EXAMINATION PAPERS. By L. J. Ryan. Cloth, 2*s.*

——— Key to Ditto. 1*s.* 6*d.*

SONNENSCHEIN AND NESBITT'S ARITHMETIC. The Science and Art of Arithmetic for the use of Schools. Post 8vo. 5*s.* 6*d.* Or separately, Part I.—Integral. 2*s.* 6*d.* Parts II. and III.—Fractional and Approximate Calculations. 3*s.* 6*d.* Answers to the Exercises. 1*s.* 6*d.* Exercises separately. Part I. 1*s.* Parts II. and III. 1*s.* 3*d.*

——— A B C OF ARITHMETIC. Teacher's Book, Nos. 1 and 2, each 1*s.* Exercise Book, Nos. 1 and 2, each 4*d.*

WALKINGAME'S TUTOR ASSISTANT (FRASER'S). Being a Compendium of Arithmetic and a Complete Question Book. 12mo. 2*s.* Key, 3*s.*

EUCLID, THE FIRST BOOK OF. With an Introduction and Collection of Problems for the use of Schools. By J. M. Wilson, M.A. *2nd edition.* 4to. 2*s.*

EUCLID, THE FIRST SIX BOOKS, together with the ELEVENTH and TWELFTH. From the Text of Dr. Simson. *New edition*, revised and corrected by S. Maynard. 18mo. 4*s.*

MODERN LANGUAGES.

French.

BARRÈRE (A.) PROFESSOR, R.M.A. Woolwich.

——— RÉCITS MILITAIRES. Selections from modern French authors, with short biographical introductions in French, and English notes for the use of army students and others. Crown 8vo. 3*s.*

——— PRÉCIS OF COMPARATIVE FRENCH GRAMMAR AND IDIOMS, and Guide to Examinations. Cloth. *Second edition, revised,* 3*s.* 6*d.*

——— JUNIOR GRADUATED FRENCH COURSE affording materials for Translation, Grammar, and Conversation. Being an introduction to the Graduated French Course. Cloth, 1*s.* 6*d.*

——— ELEMENTS OF FRENCH GRAMMAR AND FIRST STEPS IN IDIOMS. With numerous Exercises and a Vocabulary, being an Introduction to the Précis of Comparative French Grammar. Crown 8vo. cloth, 2*s.*

BELLENGER'S MODERN FRENCH CONVERSATION. Containing Elementary Phrases and New Easy Dialogues, in French and English, on the most familiar subjects. 12mo. 2*s.* 6*d.*

BOSSUT'S FRENCH WORD BOOK. 18mo. 1*s.*

—— FRENCH PHRASE BOOK. 18mo. 1*s.*

BOWER. PUBLIC EXAMINATION FRENCH READER. With a Vocabulary to every extract, suitable for all Students who are preparing for a French Examination. By A. M. Bower, F.R.G.S., late Master in University College School, &c. Cloth, 3*s.* 6*d.*

"The book is a very practical and useful one, and it must prove very handy for students who are preparing for a French examination, the persons for whose special aid it has been specially provided. It would also serve admirably for use in schools as a class book."—*Schoolmaster.*

DELILLE'S FRENCH GRAMMAR. In Two Parts. I.—Accidence. II.—Syntax, written in French, with Exercises conducive to the speaking of the French Language, &c. 12mo. 5*s.* 6*d.* Key, 3*s.*

—— EASY FRENCH POETRY FOR BEGINNERS; or, Short Selections in Verse on a Graduated Plan for the Memory. With English Notes. 12mo. 2*s.*

DELILLE'S MODÈLES DE POÉSIE FRANÇAIS. With Treatise on French Versification. *New edition.* 12mo. 6*s.*

—— RÉPERTOIRE DES PROSATEURS FRANCAIS. With Biographical Sketches, &c. *New edition.* 12mo. 6*s.* 6*d.*

—— MANUEL ÉTYMOLOGIQUE; or, an Interpretative Index of the most recurrent Words in the French Language. 12mo. 2*s.* 6*d.*

—— BEGINNER'S OWN FRENCH BOOK. Being a Practical and Easy Method of Learning the Elements of the French Language. 12mo. cloth, 2*s.* Key, 2*s.*

DES CARRIÈRES' FRENCH IDIOMATICAL PHRASES AND FAMILIAR DIALOGUES. Square, 3*s.* 6*d.*

DES CARRIÈRES' HISTOIRE DE FRANCE, DEPUIS L'ETABLISSEMENT DE LA MONARCHIE. Continuée jusqu'au rétablissement de l'Empire sous Napoleon III., par C. J. Delille. 12mo. 7*s.*

DUVERGER'S COMPARISON BETWEEN THE IDIOMS, GENIUS, AND PHRASEOLOGY OF THE FRENCH AND ENGLISH LANGUAGES. *New edition.* 12mo. 4*s.* 6*d.*

GASC (F. E. A.) AN IMPROVED MODERN POCKET DICTIONARY OF THE FRENCH AND ENGLISH LANGUAGES. *New edition.* 16mo. cloth, 2*s.* 6*d.* Also in 2 vols. in neat leatherette, 5*s.*

——— MODERN FRENCH-ENGLISH AND ENGLISH-FRENCH DICTIONARY. *New edition, revised.* In 1 vol. 8vo. 10*s.* 6*d.*

HAMEL'S NEW UNIVERSAL FRENCH GRAMMAR. *New Edition.* 12mo. 4*s.*

——— GRAMMATICAL EXERCISES UPON THE FRENCH LANGUAGE. *New edition.* 12mo. 4*s.* Key, 3*s.*

——— FRENCH GRAMMAR AND EXERCISES. *New edition.* 12mo. 5*s.* 6*d.* Key, 4*s.*

LEVIZAC'S DICTIONARY OF THE FRENCH AND ENGLISH LANGUAGES. *New edition*, by N. Lambert. 12mo. 6*s.* 6*d.*

NUGENT'S POCKET DICTIONARY OF THE FRENCH AND ENGLISH LANGUAGES. *New edition*, revised by J. C. J. Tarver. *Pearl edition*, 4*s.* 6*d.*

OLLENDORFS (Dr. H. G.) NEW METHOD OF LEARNING TO READ, WRITE, AND SPEAK A LANGUAGE IN SIX MONTHS. Adapted to the French. *New edition.* 12mo. 6*s.* 6*d.* Key, 8vo. 7*s.*

PRACTICAL COMMERCIAL CORRESPONDENCE. *See Miscellaneous.*

Whittaker's French Series.

For the use of Schools and Private Students. Edited by A. Barrère, Prof. R.M.A. Woolwich, &c., and others. Each number with a literary Introduction and Arguments in English, foot-notes explaining the more difficult passages, and translations of the idiomatic expressions into the corresponding English idioms.

Fcap. 8vo, each number, sewed, 6*d.* ; cloth, 9*d.*

Now Ready :—

1. SCRIBE. LE VERRE D'EAU. Barrère.
2. MOLIERE. LE BOURGEOIS GENTILHOMME. Gasc.
3. MOLIERE. L'AVARE. Gasc.
4. SOUVESTRE. SOUS LA TONNELLE. Desages.
5. MOLIERE. LE MISANTHROPE. Gasc.
6. GALLAND. ALI BABA. Clare.
7. CORNEILLE. LE CID. Gasc.

8, 9. LAMARTINE. JEANNE D'ARC. Barrère.

10, 11. PIRON. LA METROMANIE. Delbos.

Others to follow.

Whittaker's French Classics, with English Notes.

Fcap. 8vo. cloth.

AVENTURES DE TELEMAQUE. Par Fénélon. *New edition.* Edited and revised by C J. Delille. 2*s.* 6*d.*

HISTOIRE DE CHARLES XII. Par Voltaire. *New edition.* Edited and revised by L. Direy. 1*s.* 6*d.*

PICCIOLA. Par X. B. Saintine. *New edition.* Edited and revised by Dr. Dubuc. 1*s.* 6*d.*

SELECT FABLES OF LA FONTAINE. *New edition.* Edited by F. Gasc, M.A. 1*s.* 6*d.*

Whittaker's Series of Modern French Authors.

WITH INTRODUCTION AND NOTES.

For Beginners.

LA BELLE NIVERNAISE. Histoire d'un vieux bateau et de son équipage. By Alphonse Daudet. With 6 illustrations. Edited by James Boïelle, Senior French Master at Dulwich College. 2*s.* 6*d.* [*Ready.*

For Advanced Students.

BUG JARGAL. By Victor Hugo. Edited by James Boïelle, Senior French Master at Dulwich College. 3*s.* [*Ready.*

Others to follow.

German.

FLÜGEL'S COMPLETE DICTIONARY OF THE GERMAN AND ENGLISH LANGUAGES. Comprising the German and English, and English and German. Adapted to the English Student, with great Additions and Improvements. By C. A. Feiling, A. Heimann, and J. Oxenford. *New edition.* 2 vols. 8vo. 1*l.* 1*s.*

——— ABRIDGED GERMAN AND ENGLISH, AND ENGLISH AND GERMAN DICTIONARY. Carefully compiled from the larger Dictionary. By C. A. Feiling and J. Oxenford. *New edition.* Royal 18mo. 6*s.*

GRENFELL'S ELEMENTARY GERMAN EXERCISES. Part I. Adapted to the Rugby School German Accidence. 12mo. 1*s.* 6*d.*

OLLENDORFF'S (Dr. H. S.). NEW METHOD OF LEARNING TO READ, WRITE, AND SPEAK A LANGUAGE IN SIX MONTHS. Adapted to the German *New edition.* Crown 8vo. 7*s.* Key, 8vo. 7*s.*

SHELDON (E.S.) A SHORT GERMAN GRAMMAR FOR HIGH SCHOOLS AND COLLEGES. Crown 8vo. 3*s.*

WHITTAKER'S COURSE OF MODERN GERMAN. By F. Lange, Ph.D., Professor, R.M.A. Woolwich, Examiner in German to the College of Preceptors, London; Examiner in German at the Victoria University, Manchester, and J. F. Davis, M.A., D.Lit. Extra fcap. 8vo. cloth.

A CONCISE GERMAN GRAMMAR. With especial reference to Phonology, Comparative Philology, English and German Correspondences, and Idioms. By Frz. Lange, Ph.D., Professor at the Royal Military Academy, Woolwich. In three Parts. Part I., Elementary, 2*s.* Part II., Intermediate, 2*s.* Part III. in the press.

ELEMENTARY GERMAN READER. A Graduated Collection of Readings in Prose and Poetry. With English Notes and a Vocabulary. By F. Lange, Ph.D. 1*s.* 6*d.*

ADVANCED GERMAN READER. A Graduated Collection of Readings in Prose and Poetry. With English Notes and a Vocabulary. By F. Lange, Ph.D. and J. F. Davis, M.A., D.Lit. [*Nearly ready.*

PROGRESSIVE GERMAN EXAMINATION COURSE. In Three Parts. By F. Lange, Ph.D., Prof. R.M.A., Woolwich, Examiner in German to the College of Preceptors.

Comprising the Elements of German Grammar, an Historical Sketch of the Teutonic Languages, English and German Correspondences, Materials for Translation, Dictation, Extempore, Conversation and complete Vocabularies.

1. ELEMENTARY COURSE. Cloth, 2*s.*
2. INTERMEDIATE COURSE. Cloth, 2*s.*
3. ADVANCED COURSE. Second revised edition. Cloth, 1*s.* 6*d.*

"We cordially commend it as a useful help to examiners, who will find it well adapted to their needs."—*Practical Teacher.*

In Preparation.

GERMAN CONVERSATIONAL DICTIONARY. A Guide to Modern German Conversation. For the Every-day Purposes of Travellers and Students. By G. May and J F. Davis, M.A., D.Lit.

German Classics, with English Notes.

Fcap. 8vo. cloth.

GERMAN BALLADS. From Uhland, Goethe, and Schiller. With Introductions to each Poem, copious Explanatory Notes, and Biographical Notices. By C. Bielefeld. 1*s*. 6*d*.

GOETHE'S HERMANN AND DOROTHEA. With Short Introduction, Argument, and Notes Critical and Explanatory. By Ernest Bell and E. Wölfel. 1*s*. 6*d*.

SCHILLER'S MAID OF ORLEANS. With Introduction and Notes. By Dr. Wagner. 1*s*. 6*d*.

—— MARIA STUART. With Introduction and Notes. By V. Kastner, M.A. 1*s*. 6*d*.

—— WALLENSTEIN. Complete Text. *New edition*. With Notes, Arguments, and an Historical and Critical Introduction. By C. A. Buchheim, Professor, Ph.D., 5*s*. Or separately—Part I.—THE LAGER AND DIE PICCOLOMINI. 2*s*. 6*d*. Part II.—WALLENSTEIN'S TOD. 2*s*. 6*d*.

Whittaker's Series of Modern German Authors.

With Introduction and Notes. Edited by F. Lange, Ph.D., Professor, Royal Military Academy, Woolwich.

The attention of the heads of Colleges and Schools is respectfully directed to this new Series of "MODERN GERMAN AUTHORS" which is intended to supply the much-felt want of suitable Reading Books for English Students of German who have passed through the preliminary stages of fables and anecdotes.

To those who wish to extend their linguistic and grammatical knowledge, these volumes will afford, in one respect, a great advantage over those of an earlier period, presenting, as they do, the compositions of the best living, or only recently deceased authors. The Notes, besides etymological and other explanations, will contain many useful idiomatic expressions suggested by the text, and worth committing to memory.

FIRST SERIES.

FOR BEGINNERS. Edited, with a Grammatical Introduction, Notes, and a Vocabulary, by F. Lange, Ph.D., Professor, R.M.A. Woolwich, Examiner in German to the College of Preceptors, and H. Hager, Ph.D., Examiner in German to the London University.

HEY'S FABELN FÜR KINDER. Illustrated by O. Speckter. Edited, with an Introduction, Grammatical Summary, Words, and a complete Vocabulary. By F. Lange, Ph.D., Professor. 1*s.* 6*d.*

THE SAME, with a Phonetic Introduction, Phonetic Transcription of the Text. By F. Lange, Professor, Ph.D. 2*s.*

SECOND SERIES.

FOR INTERMEDIATE STUDENTS. Edited, with a Biographical Introduction, Notes, and a complete vocabulary, by F. Lange, Ph.D., Professor, and H. Hager, Ph.D.

DOKTOR WESPE. Lustspiel in fünf Aufzügen von JULIUS RODERICH BENEDIX. Edited by F. Lange, Ph.D., Professor. 2*s.* 6*d.*

SCHILLER'S JUGENDJAHRE. Erzählung von FRZ. HOFFMANN. Edited by H. Hager, Ph.D., Professor. [*In the press.*

THIRD SERIES.

FOR ADVANCED STUDENTS. Edited, with a Literary Introduction and Notes, by F. Lange, Ph.D., Professor, R.M.A. Woolwich, in co-operation with F. Storr, B.A.; A. A. Macdonell, M.A.; H. Hager, Ph.D.; C. Neuhaus, Ph.D. and others.

MEISTER MARTIN, der Küfner. Erzählung von E. T. A. Hoffman. Edited by F. Lange, Ph.D., Professor, Royal Military Academy, Woolwich. 1*s.* 6*d.*

HANS LANGE. Schauspiel von Paul Heyse. Edited by A. A. Macdonell, M.A., Ph.D., Taylorian Teacher, University, Oxford. 2*s.*

AUF WACHE. Novelle von Berthold Auerbach. DER GEFRORENE KUSS. Novelle von Otto Roquette. Edited by A. A. Macdonell, M.A. 2*s.*

DER BIBLIOTHEKAR. Lustspiel von G. von Moser. Edited by F. Lange, Ph.D. Second revised Edition. 2*s.*

EINE FRAGE. Idyll von George Ebers. Edited by F. Storr, B.A., Chief Master of Modern Subjects in Merchant Taylor's School. 2*s.*

DIE JOURNALISTEN. Lustspiel von Gustav Freytag. Edited by Professor F. Lange, Ph.D. Second revised Edition. 2*s.* 6*d.*

ZOPF UND SCHWERT. Lustspiel von Karl Gutzkow. Edited by Professor F. Lange, Ph.D. 2*s.* 6*d.*

GERMAN EPIC TALES IN PROSE. I. Die Nibelungen, von A. F. C. Vilmar.—II. Walther und Hildegund, von Albert Richter. Edited by Karl Neuhaus, Ph.D., the International College, Isleworth. 2*s.* 6*d.*

Italian.

BARETTI'S DICTIONARY OF THE ENGLISH AND ITALIAN LANGUAGES. To which is prefixed an Italian and English Grammar. *New Edition,* entirely re-written. By G. Comelati and J. Davenport. 2 vols. 8vo. 1*l.* 1*s.*

GRAGLIA'S NEW POCKET DICTIONARY OF THE ITALIAN AND ENGLISH LANGUAGES. With considerable Additions, and a Compendious Elementary Italian Grammar. 18mo. 4*s.* 6*d.*

OLLENDORFF'S (DR. H. G.) NEW METHOD OF LEARNING TO READ, WRITE, AND SPEAK A LANGUAGE IN SIX MONTHS. Adapted to the Italian. *New Edition.* Crown 8vo. 7*s.* Key, 8vo. 7*s.*

SOAVE'S NOVELLE MORALI. *New Edition.* 12mo. 4*s.*

VENERONI'S COMPLETE ITALIAN GRAMMAR. By P. Rosteri. 12mo. 6*s*.

VERGANI AND PIRANESI'S ITALIAN AND ENGLISH GRAMMAR. With Exercises, &c. By J. Guichet. *New edition*, by Signor A. Tommasi. 12mo. 5*s*. Key, 3*s*.

Russian.

DOLBESHOFF (E.) A DICTIONARY OF THE RUSSIAN AND ENGLISH LANGUAGES. In two volumes. Vol. I. Russian-English. Vol. II. English-Russian. Compiled by E. Dolbeshoff in co-operation with C. E. Turner, Professor of English Language and Literature at the University, St. Petersburg. [*Preparing*.

Spanish.

NEUMAN AND BARETTI'S SPANISH AND ENGLISH, AND ENGLISH AND SPANISH DICTIONARY. Revised and enlarged by M. Seoane, M.D. 2 vols. 8vo. 1*l*. 8*s*.

——— POCKET DICTIONARY. Spanish and English, and English and Spanish. Compiled from the larger work. 18mo. 5*s*.

OLLENDORFF'S (DR. H. G.) NEW METHOD OF LEARNING TO READ, WRITE, AND SPEAK A LANGUAGE IN SIX MONTHS. Adapted to the Spanish. *New edition*. 8vo. 12*s*. Key, 8vo. 7*s*.

PONCE DE LEON'S ENGLISH SPANISH TECHNOLOGICAL DICTIONARY. 8vo. 1*l*. 16*s*. *See page* 31.

Practical Mercantile Correspondence.

A Collection of Commercial Letters and Forms, with Notes, Explanatory and Grammatical, and a Vocabulary of Commercial Terms, edited by L. Simon, Chr. Vogel, Ph.D., H. P. Skelton, W. C. Wrankmore, Leland Mason, and others. Intended as Class Books for Schools and for Self-Instruction.

Now Ready, crown 8vo, cloth:

ENGLISH, with German Notes, 3*s.*
GERMAN, with English Notes, 3*s.*
ENGLISH, with French Notes, 4*s.* 6*d.*
FRENCH, with English Notes, 4*s.* 6*d.*

This new Collection of Model Letters and Epistolary Forms embraces the whole sphere of Commercial Transactions. Each example is provided with such remarks and explanations, that any one with a fair grammatical knowledge of the particular language will find it an easy matter to prepare a well-expressed letter.

The Specialist's Series.

A New Series of Handbooks for Students and Practical Engineers. Crown 8vo. With many Illustrations.

GAS ENGINES. Their Theory and Management. By William Macgregor. With 7 Plates. Crown 8vo. pp. 245, 8*s.* 6*d.*

BALLOONING: A Concise Sketch of its History and Principles. From the best sources, Continental and English. By G. May. With Illustrations. Crown 8vo. pp. vi.-97, 2*s.* 6*d.*

ELECTRIC TRANSMISSION OF ENERGY, and its Transformation, Subdivision, and Distribution. A Practical Handbook by Gisbert Kapp, C.E., Associate Member of the Institution of Civil Engineers, &c. With 119 Illustrations. Crown 8vo. pp. xi.-331. 7*s.* 6*d.*

ARC AND GLOW LAMPS. A Practical Handbook on Electric Lighting. By Julius Maier, Ph.D., Assoc. Soc. Tel. Eng., &c. With 78 Illustrations. Crown 8vo. pp. viii.-376. 7*s.* 6*d.*

ON THE CONVERSION OF HEAT INTO WORK. A Practical Handbook on Heat-Engines. By William Anderson, M. Inst. C.E. With 64 Illustrations. Pp. viii.-254. Cr. 8vo. 6*s*.

SEWAGE TREATMENT, PURIFICATION AND UTILIZATION; A Practical Manual for the Use of Corporations, Local Boards, Officers of Health, Inspectors of Nuisances, Chemists, Manufacturers, Riparian Owners, Engineers and Ratepayers. By J. W. Slater, F.E.S., Editor of "Journal of Science." Crown 8vo. cloth, price 6*s*.

THE TELEPHONE. By W. H. Preece, F.R.S., and J. Maier, Ph.D. With numerous illustrations. Cr. 8vo. 12*s*. 6*d*.

MANURES, OR THE PHILOSOPHY OF MANURING. By Dr. A. B. Griffiths, F.R.S.Ed., F.C.S., Principal and Lecturer on Chemistry in the School of Science, Lincoln, &c., &c. Cr. 8vo. 7*s*. 6*d*.

HYDRAULIC MOTORS: TURBINES AND PRESSURE MOTORS. By George R. Bodmer, Assoc. M.Inst.C.E. 14*s*.

ALTERNATING CURRENTS OF ELECTRICITY. By Thomas H. Blakesley, M.A., M.Inst.C.E. 4*s*. 6*d*.

In preparation.

GALVANIC BATTERIES. By Professor George Forbes, M.A.

INDUCTION COILS. By Professor A. J. Fleming, M.A., D.Sc.

THE DYNAMO. By Guy C. Fricker.

Others to follow.

NIPHER (F. E.) THEORY OF MAGNETIC MEASUREMENTS, WITH AN APPENDIX ON THE METHOD OF LEAST SQUARES. One volume. Crown 8vo. cloth, 5*s*.

PLANTÉ (G.) THE STORAGE OF ELECTRICAL ENERGY, and Researches in the Effects created by Currents combining Quantity with High Tension. Translated from the French by Paul Bedford Elwell. With Portrait, and 89 Illustrations. 8vo. pp. vii.-268, cloth, 12*s*.

Small crown 8vo. cloth. With many Illustrations.

Whittaker's Library of Arts, Sciences, Manufactures and Industries.

MANAGEMENT OF ACCUMULATORS AND PRIVATE ELECTRIC LIGHT INSTALLATIONS. A Practical Handbook by Sir David Salomons, Bart., M.A. 4th Edition, Revised and Enlarged, with 32 Illustrations. Cloth, 3*s*.

"To say that this book is the best of its kind would be a poor compliment, as it is practically the only work on accumulators that has been written."—*Electrical Review.*

ELECTRICAL INSTRUMENT-MAKING FOR AMATEURS. A Practical Handbook. By S. R. Bottone, Author of "The Dynamo," &c. With 60 Illustrations. Third edition. Cloth, 3*s*.

ELECTRIC BELLS AND ALL ABOUT THEM. A Practical Book for Practical Men. By S. R. Bottone. With more than 100 illustrations. Cloth, 3*s*.

PRACTICAL IRON FOUNDING. By the Author of "Pattern Making," &c., &c. Illustrated with over one hundred engravings. Cloth, 4*s*.

THE PROTECTION OF BUILDINGS FROM LIGHTNING. A Treatise on the Theory of Lightning Conductors from a Modern Point of View. Being the substance of two lectures delivered before the Society of Arts in March, 1888. By Oliver J. Lodge, LL.D., D.Sc., F.R.S., Professor of Physics in University College, Liverpool.

Published with various amplifications and additions, with the approval of the Society of Arts. [*In preparation.*

ELECTRICAL INFLUENCE MACHINES: Containing a full account of their historical development, their modern Forms, and their Practical Construction. By J. Gray. B.Sc. [*In the press.*

ELECTRICAL ENGINEERING IN OUR HOMES AND WORKSHOPS. A Practical Handbook. By Sydney F. Walker, M.Inst.C.E., M.I.E.E. [*Immediately.*

Others in preparation.

Technological Dictionaries.

ENGLISH AND GERMAN.

WERSHOVEN (F. J.) TECHNOLOGICAL DICTIONARY OF THE PHYSICAL, MECHANICAL, AND CHEMICAL SCIENCES. English and German. 2 vols. cloth, 5*s*.

ENGLISH—SPANISH.

PONCE DE LEON. TECHNOLOGICAL DICTIONARY. English-Spanish and Spanish-English. Containing Terms employed in the Applied Sciences, Industrial Arts, Mechanics, Fine Arts, Metallurgy, Machinery, Commerce, Ship-building and Navigation, Civil and Military Engineering, Agriculture, Railway Construction, Electro-technics, &c.

Vol. I.—English-Spanish. 8vo. bound, £1 16*s*.

Vol. II.—Spanish-English. [*In preparation.*

Post 8*vo.* 814 *pp.* 10*s.* 6*d.*

HOBLYN'S DICTIONARY OF TERMS USED IN MEDICINE AND COLLATERAL SCIENCES. 11*th edition*. Revised throughout, with numerous Additions. By John A. P. Price, B.A., M.D. Oxon., Assistant-Surgeon to the Royal Berkshire Hospital.

This new edition has undergone complete revision and emendation. Many terms, fallen more or less into disuse, have been omitted; and a considerable amount of fresh matter has been introduced, in order to meet the requirements of the present day.

CHISWICK PRESS:—C. WHITTINGHAM AND CO., TOOKS COURT, CHANCERY LANE.